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CONTENTS

	Page
DEW POINT AS AN AIR MASS IDENTIFIER AND SOME FACTORS AFFECTING THE AUSTRALIAN REGION — J. P. Mottram	1
THE UNUSUAL WEATHER OF NEW YEAR, 1970 — P. O. Blake	10
FISHING WEATHER - KANGAROO ISLAND — D. A. R. Whitman	17
FIRE BEHAVIOUR IN "BLOW-UP" CONDITIONS — D. R. Douglas	23
MORE ON TROPICAL CYCLONE "ADA" — A. T. Brunt	30
WEATHER PREDICTIONS BY ANIMALS — from Pears Encyclopaedia	32
ADELAIDE'S RECORD RAIN — H. A. Lindsay	33
WAVES ON THE SOUTHERN COAST OF AUSTRALIA — J. Noye	37

OUR FIRST YEAR

A GREAT SUCCESS

This, the second edition of Monana, marks the end of the first year of our activities, and it is very pleasing to note that our membership has now risen to 225 and the average attendance at our meetings has been over 100.

We are convinced that there are hundreds of other people who would wish to join our Association if they were told about it. Why not use this copy of Monana to show your friends what the Association has to offer - something which would be cheap at double the price. In this edition you will find two membership application forms. Additional forms are available from the Secretary.

Remember - anyone can join. The more members we have the more benefit you, and they, will derive from our Association.

President.

DEW POINT AS AN AIR MASS IDENTIFIER

AND

SOME MAJOR AIR MASSES AFFECTING THE AUSTRALIAN REGION

by

J. P. MOTTRAM

INTRODUCTION

A fundamental and often asked question in Synoptic Meteorology is "What is the Moisture Distribution?" A Meteorologist cannot attempt to make a forecast until this is known for a particular air mass. This discussion centres on the presence, identification and distribution of water vapour in the atmosphere.

MOISTURE IN THE AIR

Water vapour is the most variable of the constituents of the atmosphere. The supply is replenished invisibly, by silent evaporation of water or ice from the surface of sea and land and particularly from trees in leaf (transpiration). Eventually the water vapour condenses and precipitation results thus completing the process known as the hydrologic cycle. This is illustrated in Fig. 1. Two interesting points to note about the hydrologic cycle are, firstly, evaporation and transpiration (which together are known as evapotranspiration) can be greater over a fertile region than evaporation from the Ocean. Secondly, as the amount of water available to the earth and its environs is more or less constant over centuries, this process is essential for life, as it acts as a giant purifying plant.

Now, all air as we find it is more or less moist, and the dry air of the student of Physics is an artificial product which can only be obtained in the Laboratory by removing all the water vapour. For the Physicist then, there are no degrees of dryness. Air is either dry because it contains no water vapour at all, or it is moist in the sense that it contains some water vapour, which can be made evident as a deposit on a polished surface by sufficient cooling.

For the ordinary person and the Meteorologist, however, air is dry when it has considerable capacity for absorbing water vapour by evaporation from wet surfaces. One can make comparisons. One sample of air may be called dry and another very dry. In fact, Meteorologists speak of degrees of dryness as a counter part to degrees of humidity.

AIR MASS CONCEPT

There would be very little change in weather if air with unvarying moisture characteristics circulated over large areas of the earth all the time. This is obviously not the case. In practice, however, the general circulation of the atmosphere does cause vast

bodies of air to stagnate or move over extensive areas of uniform surface properties. Such areas are, for example, the Indian Ocean and the Australian Continent. If the air remains over such regions long enough, radiation and convection cause the vertical distribution of temperature and moisture to reach equilibrium with respect to the surface beneath. In other words the atmosphere assumes properties which are representative and characteristic of the type of underlying surface. This brings us to the concept of an air mass. Such a wide spread body of air which is approximately homogeneous in its horizontal extent is called an air mass. The region where it is formed is termed the source. In Fig. 2, a parcel of air taken from point A in a particular air mass would have similar properties to a parcel at point B in the same air mass, even though these points may be separated by several hundred miles.

Because an air mass is homogeneous, the moisture content becomes an identifying tag which can be used to trace it as it moves away from its source region.

MEASUREMENT OF WATER VAPOUR

Fundamentally, all measures of water vapour or atmospheric humidity are based on quantities relating to evaporation and condensation over flat water surfaces.

The amount of water air can hold depends on the temperature and, curiously enough, on nothing but the temperature. Warm air can hold more water vapour than cold air. For example, air at $102^{\circ}F$ is capable of holding 10 times the amount of water vapour as air at $32^{\circ}F$.

The absolute amount of water vapour which may be present is therefore related to the temperature and thus parameters of either mass or temperature can be used to describe how near to saturation are different samples of air. There are a number of ways in common useage of expressing atmospheric humidity. The two most important and often used are Relative Humidity and Dew Point Temperature.

Relative Humidity

Relative Humidity is the mass or amount of water vapour in the air at a particular time, expressed as a percentage of the total amount of water vapour it could hold, if the same sample of air were saturated.

So, if we say, for example, the relative humidity is 50%, we mean the air holds half the amount of water it is capable of holding under the same conditions of temperature and pressure.

In particular, note that relative humidity is a function of the temperature; so if, for example, the relative humidity at 9 a.m. is, say 50% with a temperature of 50°, then at noon when the temperature is, say 70°, the relative humidity would be 20% with no change in the actual amount of water vapour present.

The different relative humidity values are simply due to the fact that warmer air is capable of holding more moisture. Thus, for the Meteorologist trying to keep track of a particular air mass with a particular absolute moisture content, relative humidity is of very limited value.

Dew Point Temperature

In synoptic meteorology, Dew Point Temperature is a much more useful measure of water vapour because it is relatively conservative. In other words it is a property which remains constant and is not subject to diurnal change.

It is possible to take a sample of air with a relative humidity of 50% and, by cooling it, reach a temperature at which the water vapour content is sufficient to saturate it. During the cooling process the relative humidity gradually increases from 50% until it reaches 100%, although the actual amount of water vapour has been constant all the time. The temperature when saturation occurs is called the dew point temperature.

Thus, in an air mass cooling overnight, the dew point is the temperature when the air becomes saturated and dew is deposited. The dew point temperature, unlike relative humidity, depends only on the actual amount of water vapour present, i.e. in a given air mass all stations in that air mass will report a similar dew point. Dew point is thus conservative and very important in synoptic meteorology.

METHODS AND INSTRUMENTS USED TO MEASURE WATER VAPOUR CONTENT OF THE AIR

The most obvious way to measure the amount of water vapour present is to pass a sample of air over some absorbing substance or chemical (e.g. H_2SO_4 and certain salts such as calcium chloride and magnesium chloride) and by weighing the substance before and after, the amount of water vapour is determined. This rather precise method is more suited to Laboratory work.

Because of small and often rapid fluctuations in atmospheric humidity, the refinement of Laboratory type equipment is not warranted in every day meteorology, and a more robust and reasonably accurate instrument is better suited to normal use.

The Psychrometer

Among the instruments used is the Psychrometer. Curiously this consists of two instruments, which together mounted side by side, may be regarded as a separate instrument going by the high sounding name of Psychrometer. It consists of a "wet bulb" thermometer (which is a normal thermometer with the bulb covered by a tight fitting muslin cloth, kept moist by a wick from a water reservoir) mounted together with an ordinary "dry bulb" thermometer in a Stevenson Screen. When the air flows past these two thermometers, evaporation of water from the wet bulb requires

the absorption of heat and results in a decrease in the temperature reading. The amount of evaporation, and therefore the amount of cooling, depends on the quantity of water vapour in the surrounding air and thus, the difference in the two temperature readings can be equated to the amount of moisture in the surrounding air. The difference between two readings is often referred to as the wet bulb depression.

The Sling and Assman Psychrometers use the same principle, but are of a portable nature and are often used in the open.

The Hair Hygrograph

The Hair Hygrograph is a continuous recording instrument and can be calibrated to read relative humidity directly. Any one living in the variable climates of the middle latitudes is familiar with the nuisance of doors and windows sticking in warm moist weather and being rather loose in dry conditions. This is chiefly caused by swelling of the wood with increasing humidity.

There are other normally dry organic tissues which have similar properties of changing dimension with changing humidity, for example, skin and hair. Animal hair, partly due to its fine texture, is the most sensitive, and human hair is the best. In fact human hair increases its length by approximately $2\frac{1}{2}\%$ as the air changes from dry (0% relative humidity) to saturation (100% relative humidity). Thus, human hair can provide a direct measurement of the amount of water vapour present and in fact, is the measuring element in the Hair Hygrograph, hence the name.

Radiosonde

The instruments discussed so far, are normally used to measure surface or low level humidity. However, moisture at higher levels can be of utmost importance, not only in identifying air masses but also to assess their rain producing potential. Highly significant amounts of moisture often exist from ground level to several miles up, and meteorological balloons carry radiosondes which measure, among other things, the amount of water vapour present. The humidity element in the radiosonde consists of a small glass slide coated with a chemical (LiCl) which only conducts electricity when moisture is present. The more moisture present, the better the conductivity and the greater the flow of current. The rate at which current is flowing across this slide is transmitted to a receiver on the ground, and this can be related to the actual water vapour content of the air as the balloon rises through the atmosphere.

MAJOR AIR MASSES AND SOURCES OF THE AUSTRALIAN REGION

Classification of Air Masses

Having discussed moisture in the atmosphere and seen how it can be measured, and in particular its use in providing identifying tags for different air masses it is possible to look in some detail at the major air masses and sources of the Australian Region. In simplest form these can be classified as either tropical or polar, depending on whether they are warm or cold. A further division arises on considering whether they are moist or dry, i.e. whether the source is over the Continent where there is little moisture available, or over the warm ocean areas of the tropical regions where there is an abundance of moisture. If the source region is an ocean area they are called maritime and if it is over the land they are called continental.

The major air masses and source regions affecting Australia are shown in Fig. 3.

Equatorial Air - (TYPE A)

This has its source in the equatorial regions and is very warm and supercharged with moisture with dew points of the order of 75-80°F. An example of this air mass affecting the continent, is the Summer Monsoon of northern Australia. This air mass very rarely affects the southern parts of the continent but when it does, it is a prolific rain producer.

Pacific Ocean/Indian Ocean Air - Tropical Martime - (TYPE B)

Both these air masses have similar properties, with sources over tropical ocean areas to the East and West of the continent. They are quite warm and carry considerable moisture. Dew points are in the 60-70°F range in the source region, but usually about 60°F when they reach South Australia as they do quite frequently. These are the main rain bearing air masses affecting South Australia.

Polar Maritime - (TYPE C)

This is very cold air with its source over the Antarctic Ocean near the ice cap. Because it is so cold it does not carry a great deal of moisture and dew points are generally in the range 30-40°F by the time it reaches the southern continent. This air also affects us quite frequently and is responsible for the sudden onset of severe cold snap conditions. It brings severe frosts and sometimes snow on the Mount Lofty Ranges. It can penetrate into the northern areas of the Continent and produce sharp frosts even in the tropics.

Air Mass of the Westerlies - (TYPE D)

Westerly winds normally prevail right around the Globe between 35° and 55° South and are colloquially known as the "Roaring 40's". The air mass associated with these winds can be more correctly termed as Southern Maritime. It is really a combination of (B) and (C) with temperature and moisture characteristics half way between the two. Dew points are normally between 45-55°F. This air is the one most frequently affecting southern Australia and is responsible for the cool changes and showers which occur all year round.

Australian Continental - (TYPE E)

This air mass is really a mixture of all the others, having become quite dry after a long period over the inland area. In Summer this air is very hot (temperatures in excess of 100°F) and dew points quite low, normally in the range 25-35°F and sometimes even lower. When this air is brought over southern Australia in the critical months of Summer it brings with it a very serious fire hazard.

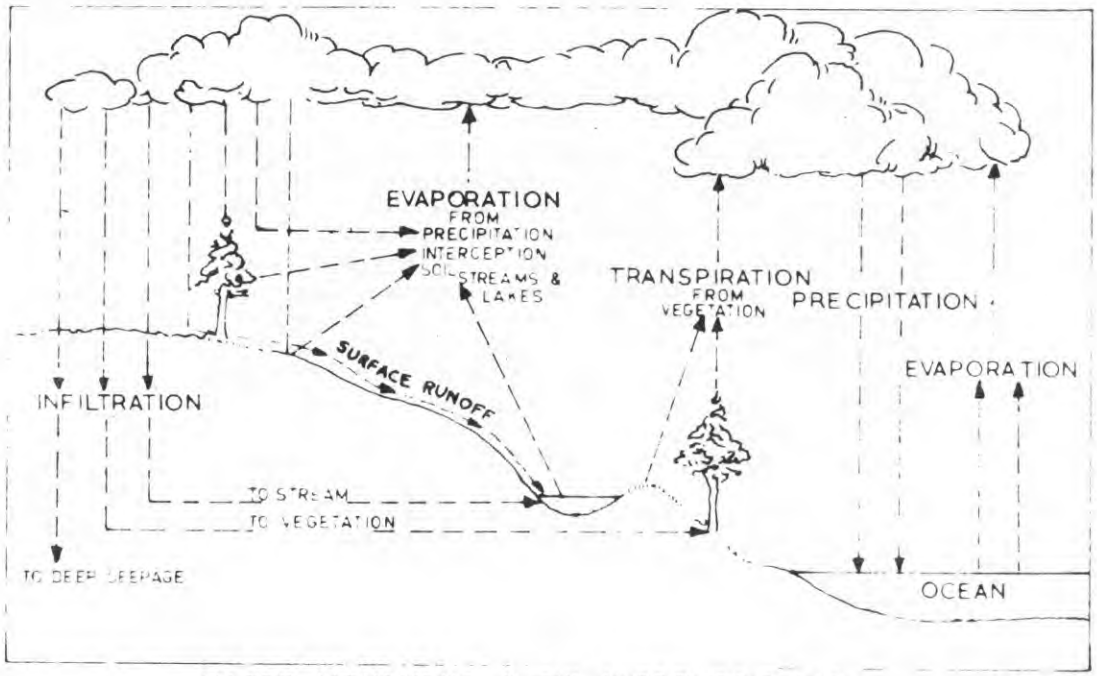
The properties of these air masses can best be illustrated by taking an example where two air masses of quite different characteristics are interacting over South Australia.

In Fig. 4 we have two different air masses, one being warm and moist with its source over the Pacific Ocean and the other being a Polar air mass from the Antarctic regions. A, B and C are representative stations reporting temperatures and dew points from the surface to upper levels. It is easily seen how the surface dew points can be used to determine the boundary between the two air masses, i.e. the frontal region.

Fig. 5 illustrates the temperature and moisture profiles above each of the stations A, B and C. This is effectively a space cross-section and shows the vertical characteristics of each of the air masses as regards temperature and dew point. This can just as easily be regarded as a time section at, for example, station B as the cold front passes through.

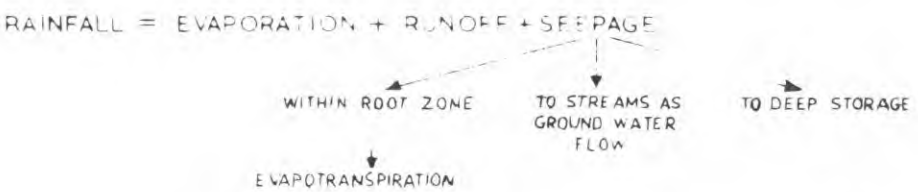
CONCLUSION

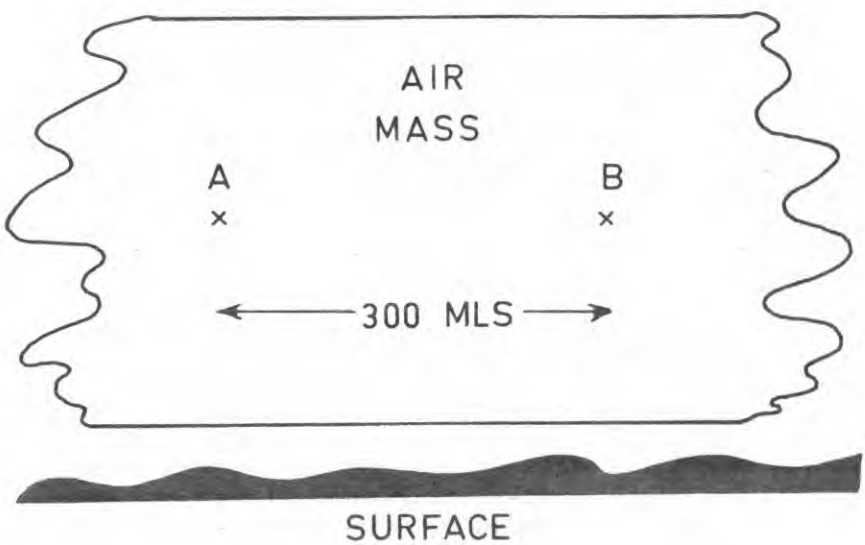
It is obvious from this discussion that accurate assessment of the amount of moisture in the air is of prime importance to the meteorologist. This assessment is frequently made more difficult due to lack of observations, and the forecaster must often rely heavily on satellite data and his own experience to analyse frontal regions over sparse data areas. Finally, not only does the moisture content of the air provide a reliable means of identifying air masses and air mass boundaries, but its presence and distribution in the air also determines such important factors as lapse rates and atmospheric stability. This most important aspect will, I believe, be discussed at a future meeting of the Association.



WATER MOVEMENT IN THE HYDROLOGIC CYCLE

FIG. 1.





Properties at A = Properties at B

FIG. 2.

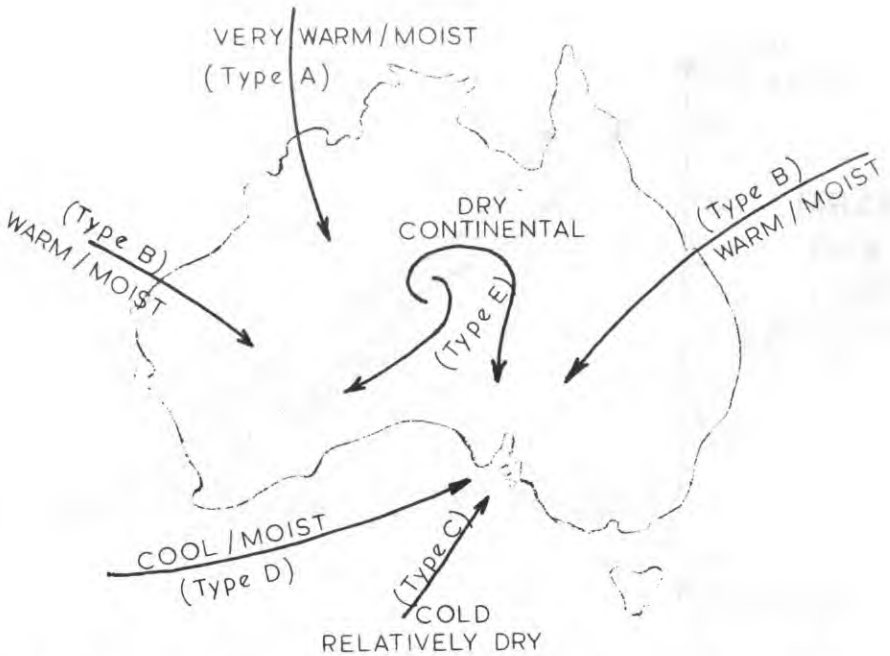


FIG. 3. MAJOR AIR MASSES AND THEIR SOURCE REGIONS.

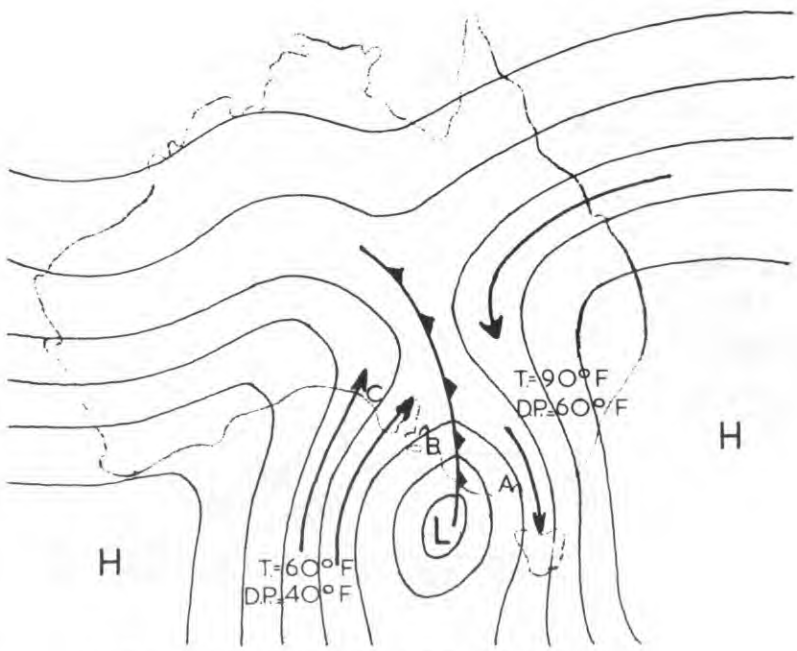


FIG. 4. M.S.L. ANALYSIS (SUMMER).

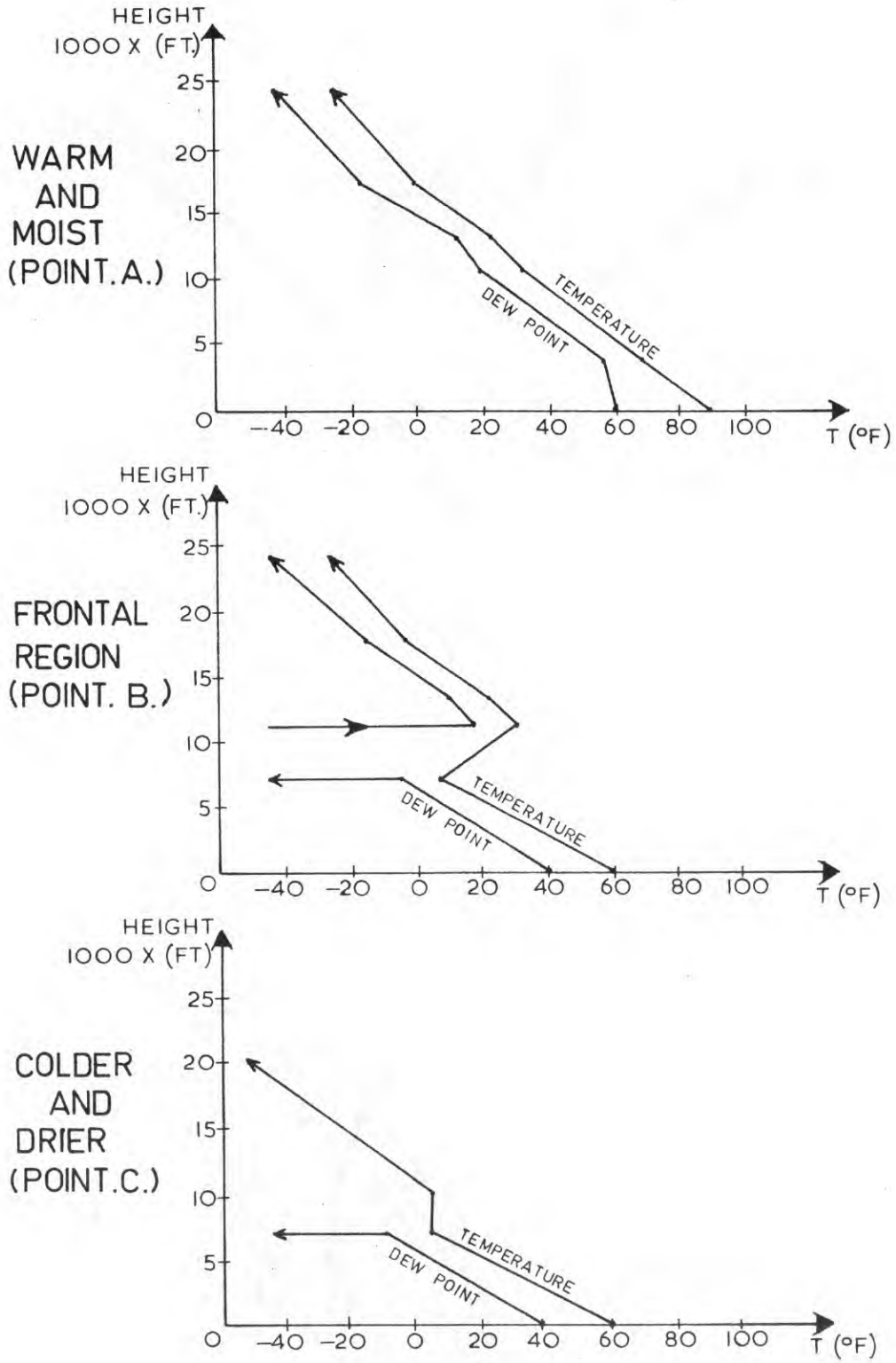

HEIGHT
1000 X (FT.)
25
20
15
10
5
0
WARM
AND
MOIST
(POINT. A.)
TEMPERATURE
DEW POINT
-40
-20
0
20
40
60
80
100
T (°F)
HEIGHT
1000 X (FT.)
FRONTAL
REGION
(POINT. B.)
TEMPERATURE
DEW POINT
HEIGHT
1000 X (FT)
COLDER
AND
DRIER
(POINT.C.)
TEMPERATURE
DEW POINT

FIG. 5.

THE UNUSUAL WEATHER OF NEW YEAR 1970

by

P.O. BLAKE

(Meteorologist)

The unusual weather pattern over the period 28 December 1969 to 4 January 1970 caused a great deal of local interest and a comparison was made of the upper air charts with the normal upper air and surface charts for Winter and Summer to illustrate the marked departure from normal conditions during the New Year period.

The weather over the New Year period 1969-1970 certainly was unusual. One might even term it crazy, or phenomenal, considering that it gave us our average January rainfall in a few days, four days in a row with a maximum temperature less than 65 degrees (average maximum for January 85.4 degrees!), the coldest New Year's Day on record and began one of the coldest Januarys on record. All this combined with strong and gusty winds, made conditions very unpleasant, particularly for outdoor New Year's Eve parties.

Now for an explanation of why it all happened.

As you know, pressure decreases with height but we do not plot changes of pressure with height. Instead, we select a pressure, say, 200 mbs, which is about 40,000 feet above the surface. This, however, varies between about 35,000 and 45,000 feet depending on the temperature distribution at the time. Therefore, we draw contours of the heights at which the particular pressure is measured.

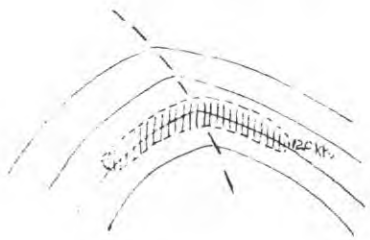
Let's start with the 200 mb level at, approximately, 40,000 feet - this level normally has the strongest winds and is an important level to watch for developments lower down in the atmosphere. The normal 200 mbs chart for January (Chart I) shows fairly straight contours i.e. constant westerly winds, with the highest wind speeds just over 50 knots. It is rare to get winds from other than the westerly quarter (Northwest to Southwest) at this level, and wind speeds, as one would expect in January, are relatively light.

The normal 200 mb (40,000 feet) chart for July (Chart II) shows a Jet maximum of over 100 knots and remember that this is the average speed for July taken over a number of years. The highest recorded speed over South Australia is about 250 knots (some 290 m.p.h.). Note the closer contour spacing and a weak trough, indicating that the greater Winter activity from deep surface depressions has some effect at 40,000 feet and vice versa.

Now let's have a look at the daily upper air charts and compare them with those that we have just seen.

On Sunday 28 December, as shown in Chart III, wind speeds were slightly in excess of normal and there was a definite trough over Western Australia. However, these did not by themselves indicate any trouble brewing, but the situation could have possibilities if the wind speeds increased or the trough sharpened markedly. It is unusual for sharp troughs to appear at this level and even more so for complete circulation (either low or high).

On Wednesday 31 December, as indicated in Chart IV, the flat trough previously over Western Australia had sharpened markedly and was associated with a Jet max. of over 120 knots (more than twice the average for January) and it was obvious at this stage that trouble was brewing in no uncertain terms because the position of the jet stream in relation to the trough was ideal for development of a surface low somewhere over New South Wales.



Firstly a note or two on the jet stream, (or jet-max. as herein referred). This is a band of very strong winds which, in a three-dimensional view, would appear something like a cigar, with strongest winds in the middle or "core". Its existence was not even suspected until it was discovered during World War II with higher flying aircraft being developed. The actual core itself may be only several thousand feet thick in the vertical and less than 100 miles across in the horizontal.

The final 200 mb chart is that for 3 January (Chart V). Here we have a complete low circulation with a marked jet max. on its northern side. The system at this stage was decaying, as wind speeds are dropping. The peak of the upper air development was reached on 1 January with a closed circulation over central New South Wales and a jet stream of over 150 knots (174 m.p.h.) associated with it.

These upper air abnormal conditions are reflected in the lower levels particularly at the 700 mb or 10,000 feet level.

Chart VI shows the 700 mbs (10,000 feet) contours for 30 December, which was the day before marked changes started occurring. Adelaide's temperature was about +4°C (39°F), which was more or less normal. Temperatures over most of southern Australia were slightly below normal.

Chart VII shows that, on 31 December, Adelaide's temperature was already down to -1°C (30°F) with very marked cold air advection in the strong south-westerly stream behind the trough. Temperatures well to the south of Adelaide are reliable (taken from actual reports). The U.S. Navy research ship "Eltanin" happened to be in the area at the time and its reports were extremely useful.

Now we come to the more familiar surface charts, which appear in the daily news paper. Surface charts are generally a reflection of upper air developments and systems, but on the other hand at times can be very misleading, depending on circumstances.

Chart VIII shows a secondary cold front advancing towards South Australia on Wednesday 31 December.

Very marked cold air advection was occurring at the surface, and also at 700 mb and other levels in the atmosphere. Also the front was approaching the area of best surface development indicated from the 200 mb level. The front reached Adelaide during the afternoon, bringing heavy rain and cold, gusty winds.

By 1 January a deep and active depression had developed over New South Wales (Chart IX) much to the annoyance of the England-Australia Air Race participants. Adelaide was in a cold southerly airstream, with strong and gusty winds. Note the position of the high - more or less in its normal position well south of the continent.

The low continued to move slowly southeast during the next few days and lost its identity on 4 January.

What caused it all? The atmosphere is a fairly finely balanced system of pressures, winds, temperatures, etc., combined with various gravitational, magnetic and electrical forces and once some of these, or even possibly only one of them, is disturbed, the system is out of balance and the weather goes haywire - not only in one locality, but more often than not on a global basis.

CHART I 200 M.B MEAN WINDS - JANUARY

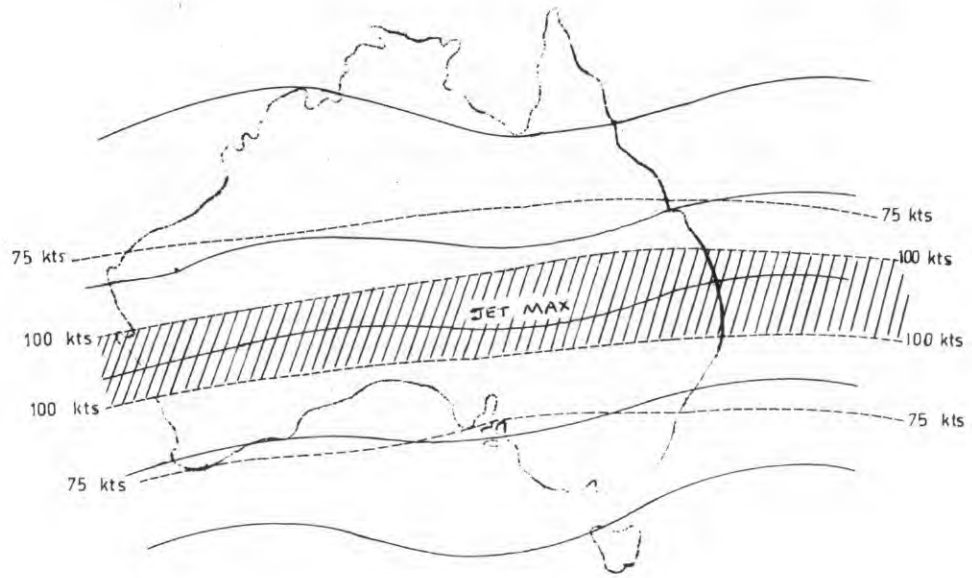


CHART 2 : 200 M.B. MEAN WINDS - JULY

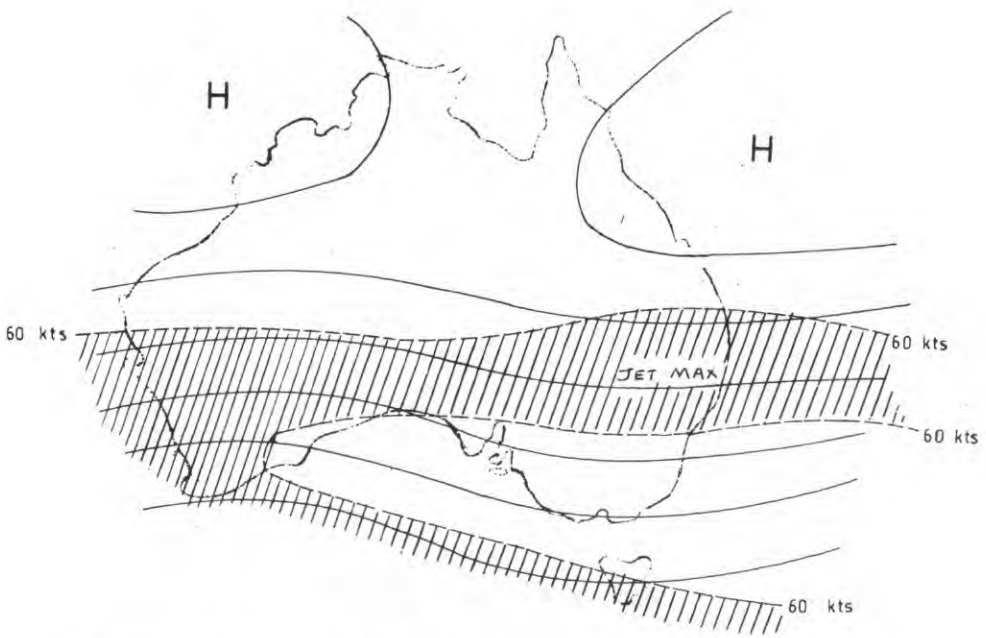


CHART 3 : 200 M.B. - 28TH. DEC. 1969.

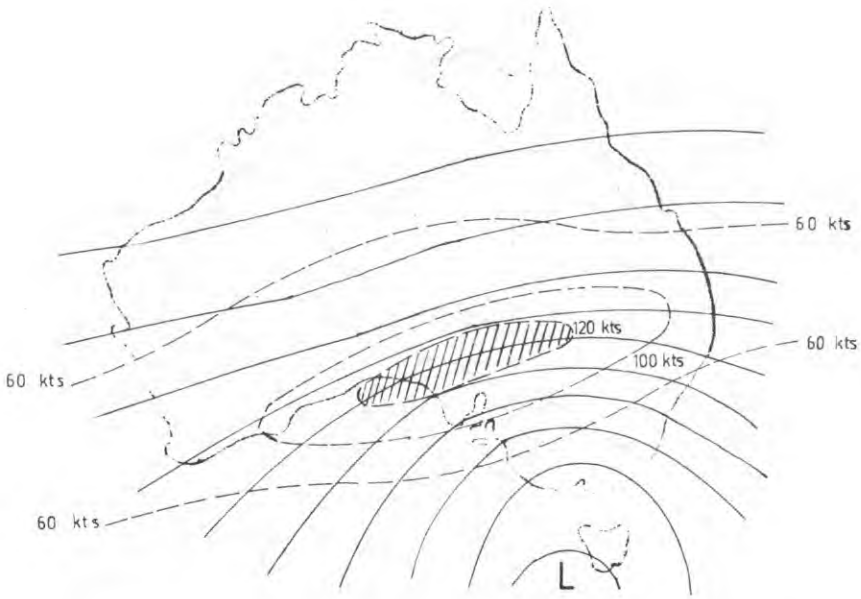
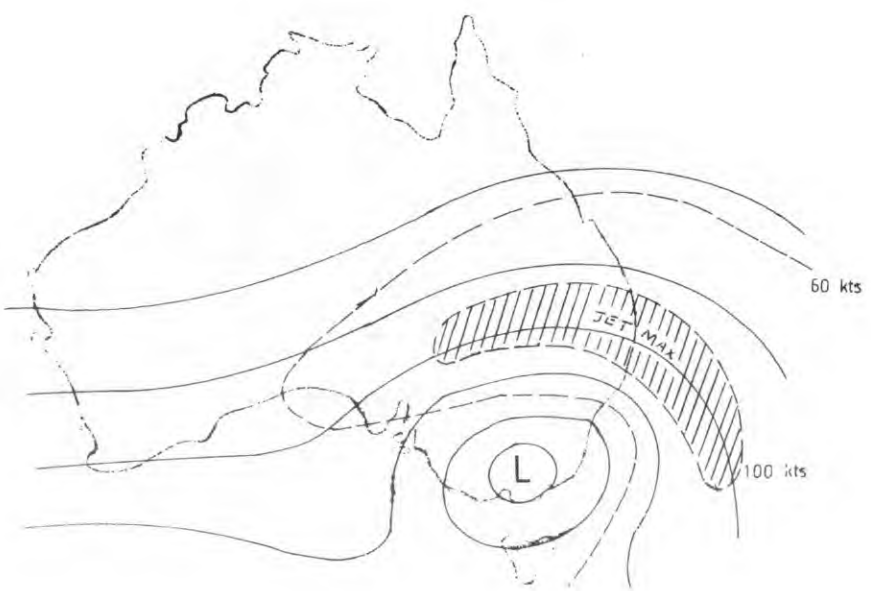


CHART 4 : 200 M.B. - 31ST. DEC. 1969.



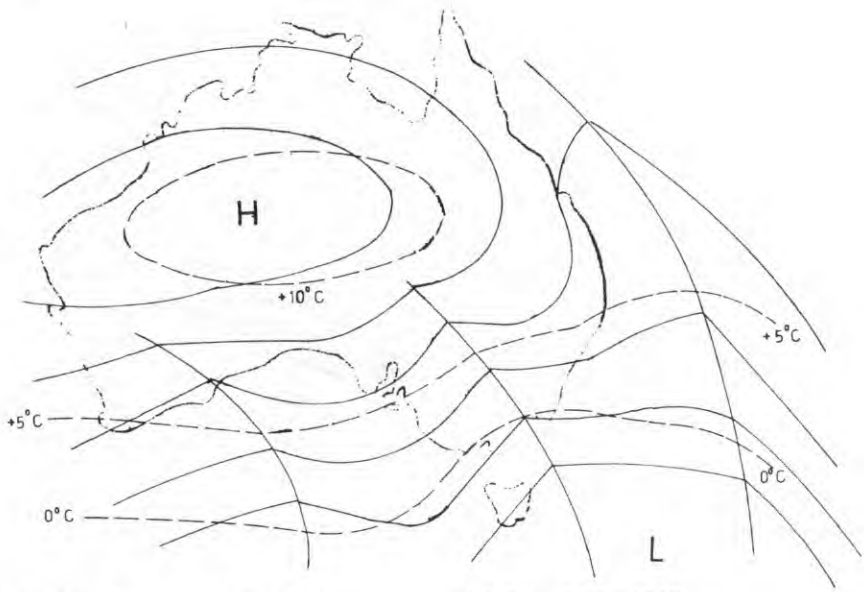


CHART 6 : 700 M.B. - 30TH. DEC. 1969.

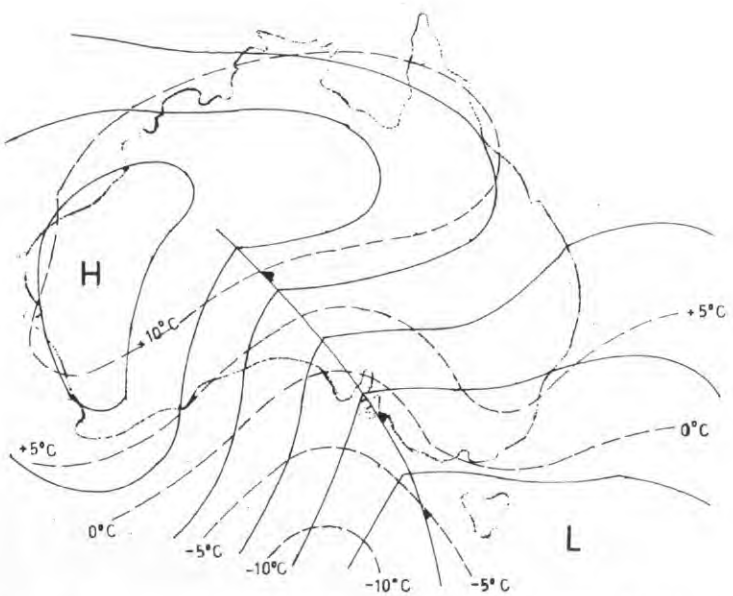


CHART 7 : 700 M.B. - 31ST. DEC. 1969.

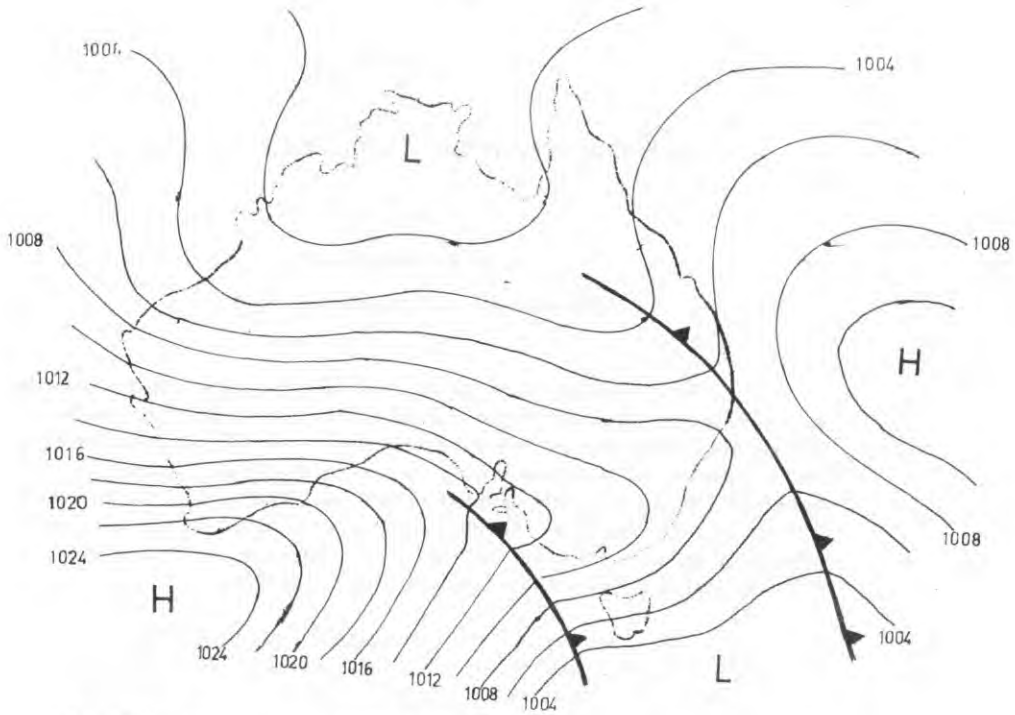


CHART 8 : SURFACE - 31ST. DEC. 1969.

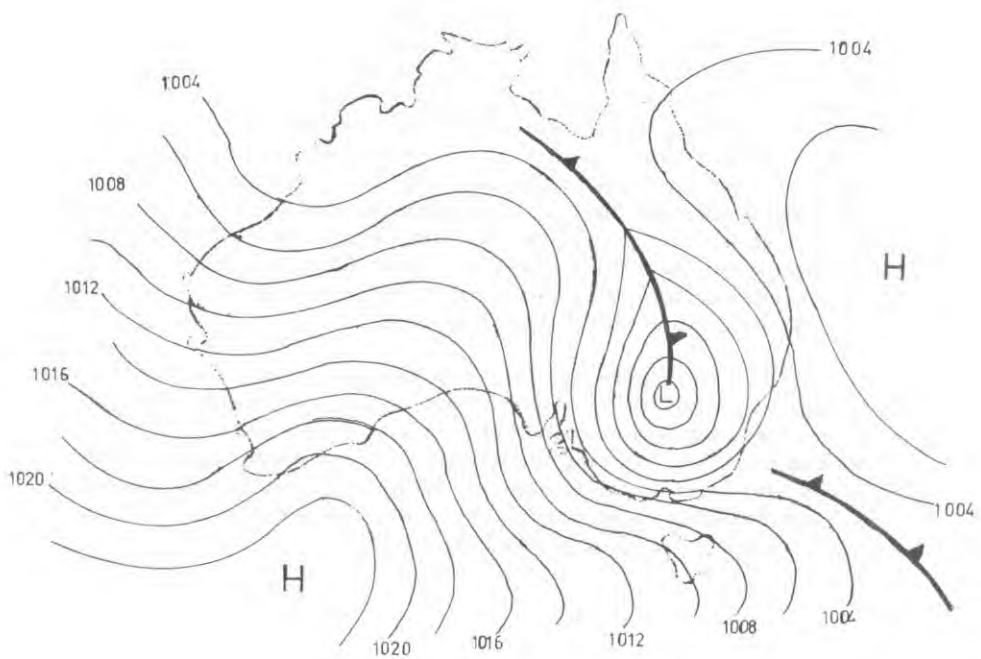


CHART 9 : SURFACE - 1ST. JANUARY, 1970.

FISHING WEATHER - KANGAROO ISLAND

by

D. A. R. WHITMAN

(Professional Fisherman, S. A.)

Mr. Hogan asked me if I would give a talk on the weather as experienced from a Professional fisherman's point of view. This I did at the August meeting last year; but for the benefit of those people who were unable to be present at that meeting, I was asked to submit something on that talk and I hope that the following will be of interest to readers, especially to those in country areas, who very seldom even see the sea, let alone sail on it and put up with its lively moods and vagaries of the weather.

There were four very rough and trying periods of weather last season, in the area in which I fish, namely, around Kangaroo Island fishing for crayfish, or, as it is now being called "rock lobster".

During the afternoon of Sunday 10 November, (1968) the weather started to deteriorate and at this time of year - November and December - it is the time of thunderstorms and westerly winds and the time to watch out in the Island area. By 9.15 a.m. the sea got up and wind freshened to something above 25 knots, so we hove anchor and left the little place called Scotts Cove, on the north coast just along from Cape Borda; put on canvas (sails) and ran before the westerly wind, which blew a hard gale before morning. The "old girl" really moved that night and we anchored at 3.15 a.m. on Monday morning 11th, at Emu Bay. (Fig. 1 - Chart for 9 a.m. - 11/11/68.) Early Tuesday 12th, it was still blowing hard and I knew that it was going to be of a few days duration, so we hove anchor at 6 a.m. and anchored at Kingscote at 8.30 a.m. and unloaded our fish. On Wednesday morning it blew harder still from the west (Fig. 2 - Chart for 9 a.m. - 13/11/68) and all that could be seen of the boats, during the squalls, from the short 200 yards distant, were the masts and spars, the hulls being lost in spume, whipped up by high winds coming over the land, across the cliff top and on to the water and out across the Bay. I waited four hours for a lull, before rowing in to the jetty, putting the dinghy on the jetty mooring, and catching the evening plane for home.

Friday evening 15th, saw us back on board and a few days fishing was done but at 6 p.m. Tuesday 19th, we had to leave Scotts Cove again and anchor at Emu Bay in the early hours of Wednesday 20th. During the day the weather moderated and the barometer went up far too quickly so we knew "it was on again" and did some fishing close handy. Thursday and Friday the wind had moderated but we knew it was only a lull.

The log book for Saturday 23 November reads "Blow, blow, blow and blow some more. (Fig. 3 - Chart for 9 a.m. - 23/11/68.) Weather pretty bad, all boats clearing out from fishing areas". Sunday was spent at anchor, watching the weather intently, hoping it would fine up but knowing full well that it would not and toward evening it freshened still further from the west'ard. Monday morning 25th, we hove anchor and "slogged" it down the coast to get some of our gear and just a few crays. We anchored at the mouth of Western River that evening with very little shelter from the driving wind. Two boats, disgusted with the weather day after day, gave us all their bait, which made us all the more determined to hang on and fish; but during the night, and a bad night at that, the wind, still sticking in the West'ard, freshened so much that we just had to heave anchor and get out. The weather report was so bad, that another Skipper and I, after talking it over put on all sail and ran before it, back to Kingscote, put our fish ashore, what little we had, put the boat on the moorings and next day caught the plane home once again.

From the log book, the period from 19 November to 28 November was all Westerly winds in that area, with only periods of a few hours let up or shift of wind - (Fig. 4 - Chart for 9 a.m. - 27/11/68).

The months of January, February and March, as you well know are our best months for Summer weather and we, in the Island area, expect better weather, in spite of quick changes, but we do get an entirely different pattern of weather and westerly and Northwest winds are out as a general rule. When the weather settles down for the Summer pattern, we get the cycle - start light Northeast today and perhaps tomorrow then freshening North the 3rd day; 4th blowing harder North, sometimes to gale force and then straight into the Southwest (no Northwest or West) and blowing pretty hard for perhaps two days, then through South quickly to Southeast where it sometimes stops for days on end and is quite pleasant once the days work is done and a haven found to anchor for the night. Of course, there are always exceptions to the rule in everything or life would be pretty dull, wouldn't it?

The period covering 23, 24 and 25 January 1969 was one of these exceptions. 23rd we had Northeast and fresh North, but 24th blew hard Northwest most of the day and, with the weather as it was, I decided to be cautious and came from Cape Bidout, on the Western end of the Island, with all the gear aboard having decided early in the afternoon not to fish. We anchored under Cape Borda waiting for the wind to "switch" as we knew it would. During late afternoon and early evening the wind died away, but before the sun set the lightning started in the North-Northwest and gradually got around to Southwest, the flashes coming out of that area of the horizon, continuously; but still the storm did not break. At 9.10 p.m. I decided to heave anchor and stand out in the Northwest direction, the wind being Northeast and about 15 knots but the "glass" was well down and still falling.

At 10 p.m. I altered course to Northeast so that when the storm did break and the wind got round to West or Southwest we would be well off shore and have a good run - "fair wind" along the coast to Emu Bay. The wind freshened against the tide and a very nasty sea got up, so that engine revolutions had to be kept down to a minimum; there was enough water coming aboard and a lot of spray to make things worse.

The night was pitch black, with flashes of lightning, and, although severe, not enough light was given for long enough periods to enable us to pinpoint our position; but the flashes from Cape Borda lighthouse and a good compass enabled me to keep a position of safety until the storm broke. Then it started raining heavily and we were thankful for good wet weather gear. At 11.10 p.m. in it came from the Northwest and blew from that quarter for 10 minutes before settling in the West and what with rain, a screaming wind, lightning and spray it was not a night to forget in a hurry, and we were very glad we had no canvas as we would certainly have blown it all out in less time than it takes to tell. Winds of 65 m.p.h. and over keep one on their toes and we had it on the night of Friday 24 January 1969 and were 25 hours out of bed during this period and much of Saturday 25th was spent in bed at anchor in Emu Bay. (Fig. 5 - Chart for 9 a.m. - 25/1/69.)

Weather in April last year was not all that fishermen could wish for and on Sunday 13th, I rang the Bureau for a report before flying back to the Island. Reassured that the weather would be alright in spite of a deep low just south of Kingscote I flew back to the Island - no wind, fine weather at Adelaide Airport - blowing hard Southeast and heavy rain Kangaroo Island Airstrip on landing. During the night the wind blew from the Southeast at 55 m.p.h. and a gust of 70 m.p.h. at Cape Willoughby. The forecaster expected that little low to move quickly away to the Southeast and so did I, instead of which it blew from that quarter for two days moderating only slowly. (Fig. 6 - Chart for 9 a.m. - 13/4/69.)

Will any of us ever know just what to expect with any certainty when winds can be so contrary?

A man who goes to sea for pleasure, or to get his living there, must be weather conscious and able to do his own forecasting - keep his eye on the "glass" and know what it does, learn the cloud patterns and the wind cycle and be always on the alert when the weather starts to deteriorate and after all, isn't this just what the man on the land must be able to do also.

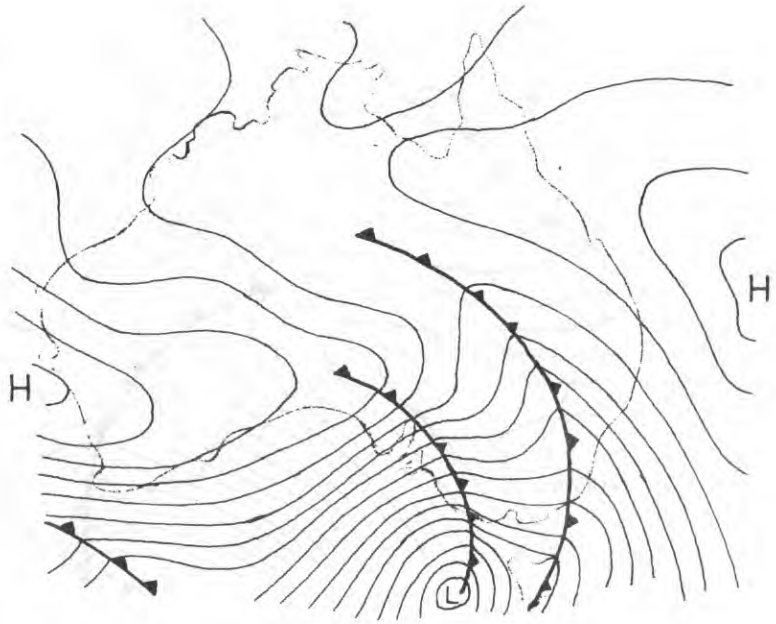


FIG. 1. 9 a.m. 11th November 1968

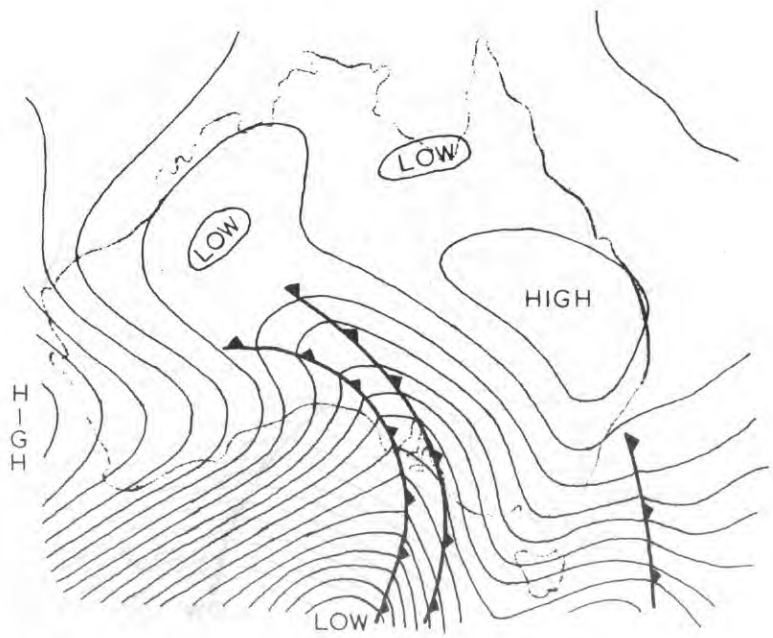


FIG. 2. 9 a.m. 13th November 1968

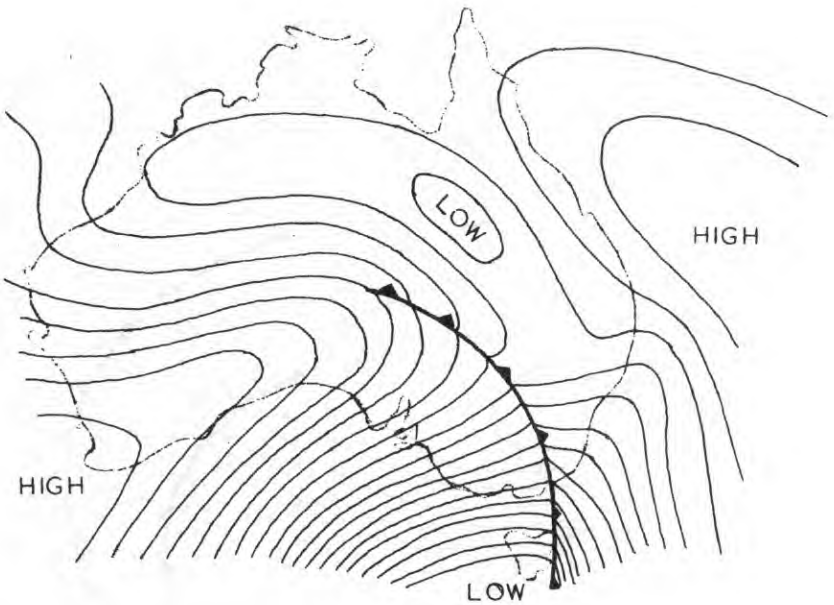


FIG. 3. 9 a.m. 23rd November 1968

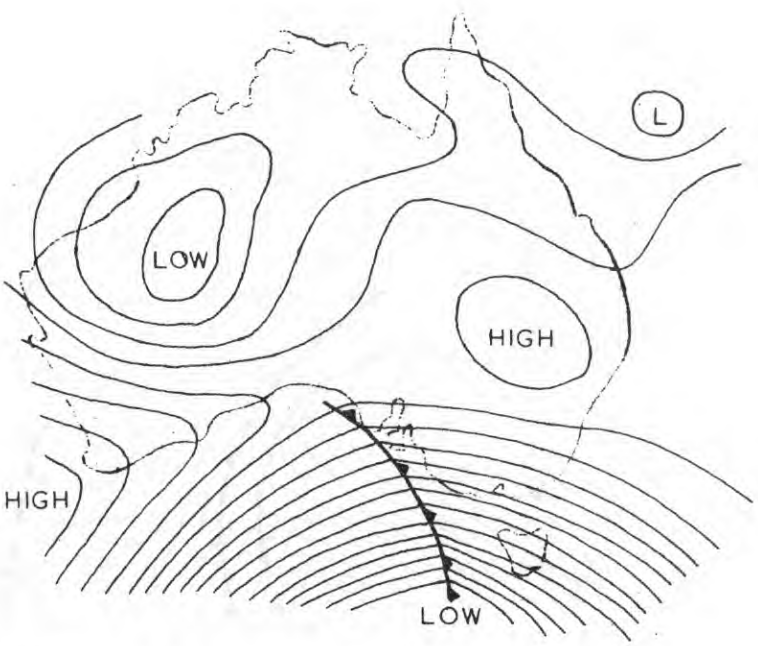


FIG. 4. 9 a.m. 27th November 1968

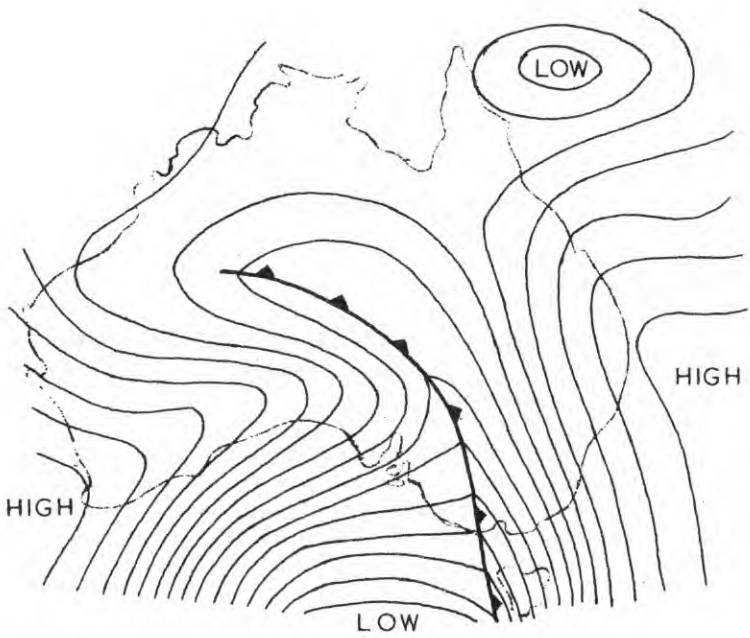


FIG.5. 9 a.m. 25th January 1969

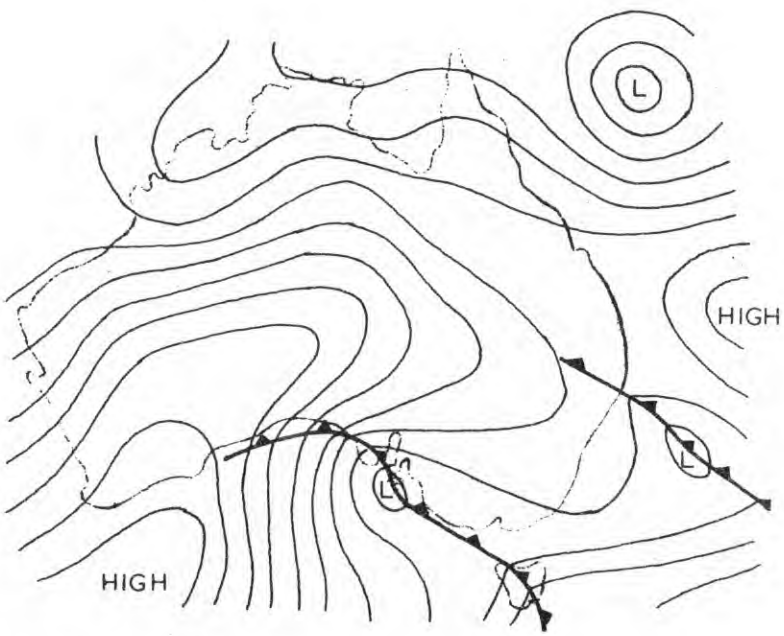


FIG.6. 9 a.m. 13th April 1969

FIRE BEHAVIOUR IN "BLOW-UP" CONDITIONS

by

D. R. DOUGLAS

(Woods & Forests Department, S. A.)

"Blow-up" Conditions

The title of this talk begs the question "What are blow-up conditions?" and it is pertinent perhaps to provide a fairly specific answer to this question.

The first criterion is a situation of relative drought and by that I mean a period over which a deficiency of soil moisture has built up as a result of which grass fuels have cured and/or the forest litter has dried out right down to mineral soil. Thus "blow-up" conditions usually require some time to build up.

In addition to relative drought a combination, on the particular day in question, of high temperatures, low dew points and high wind strengths are necessary. The more severe "blow-up" days are frequently evident to some extent during the preceding night when the night winds are very noticeable, the usual rise of overnight relative humidity is reduced to some much lower figure and the overnight minimum temperature is higher than usual.

When all these factors are integrated into a fire danger rating (McArthur 1965, 1966), days having values exceeding 50 on the 100-point scale all have the potential of being regarded as having "blow-up" characteristics.

Well over a dozen variables affect the behaviour and characteristics of fires. Fortunately only 6 or 7 of these variables, all readily measured, are controlling factors, and the study of fire behaviour tends to become a study of the inter-relationships of these particular factors.

These controlling factors are:

1. Fuel moisture content
2. Fuel quantity, size and arrangement
3. Slope
4. Wind speed, both on the surface and with increase in height
5. Atmospheric stability

In addition to these, the vital factor of time has to be borne in mind. The importance of the time factor increases as the fire danger increases and, under severe burning conditions, it is important to note that all fire behaviour characteristics (i.e. rate of fire spread, flame height, spotting potential, etc.) accelerate with time in the initial stages of the growth of the fire.

Wind and Fuel Moisture

The role of wind and fuel moisture content on fire behaviour has now been adequately explained by McArthur (1966 and 1967). Wind bends flames towards the unburnt fuel ahead of the fire and accelerates the drying of the fuel. Wind also enables burning material to be thrown ahead of the fire - sometimes only a few yards but sometimes for much greater distances. As the fuel moisture content decreases the rate of combustion and the rate of fire spread increases.

Dry litter is the essential pre-requisite to high intensity fire and the relative humidity and temperature of the air near the ground influence the moisture content of the vitally important fire fuel components.

The distribution of these fire fuel components is also a great influence on fire behaviour. Forests having a vertical distribution of dry fire fuels from ground level up to 10 to 20 feet above the ground are fertile fields for crown fire development. Crown fires burn the forests' green living leaves which are pre-heated by the flames in the dry litter below.

A useful method of limiting the possible damage in forests is to ensure that there is a good air gap between the dry ground litter and the green crowns of the trees. The elimination of the vertical arrangement of the dead fuels reduces the likelihood of crown fires.

The Lower Atmosphere

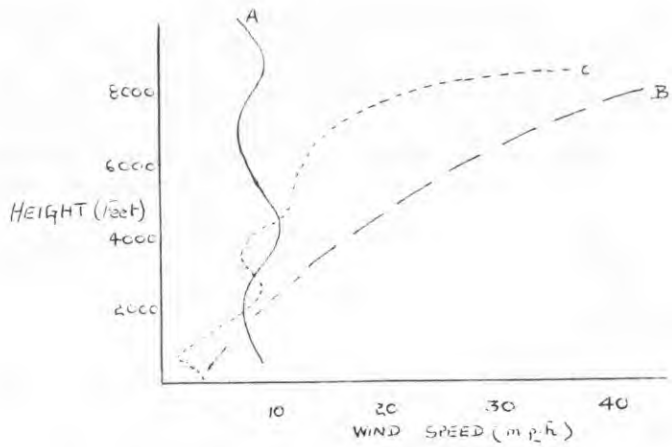
The effect of some features of the lower atmosphere on fire behaviour can be quite spectacular. Any factor which is conducive to the development of convection favours intense fire behaviour. Consequently a fire burning in unstable air forms convection columns very easily and the consequent strong indraft of air into the fire accelerates fire behaviour.

Fires burning in stable atmospheric conditions, on the other hand, are relatively much less intense. A stable atmosphere resists vertical displacement and tends to blanket convection of the fire and so limits the strengths of the indrafts of air to the base of the fire.

Another feature of the lower atmosphere influencing fire behaviour is the profile of wind speed with height.

Profile Type A can allow strong convection, and hence intense fire behaviour and large fire tornadoes.

Profile Type B causes a convection column to lean down wind and the fire behaviour tends to be affected by the prevailing ground wind rather than by indrafts induced by the convection column which almost inevitably fractures.



Profile Type C is typical of intense and spectacular fire behaviour. A strong convection column can form which is sheared off by the strong winds aloft. Fires burning in appropriate fuel types can have large burning embers carried aloft to considerable heights and then transported long distances down wind. Many spot fires can start and the problems of fire suppression are magnified tremendously.

The spotting process can be a potent force in fire spread and the fire which occurred at Daylesford, Victoria, in January 1962 is a good example. In this fire, the stringy bark eucalypt forest fuel type was conducive to spotting and the weather, of course, made its contribution.

Spot fires originated between 2 and 3 miles ahead of the main body of fire on several occasions and the spotting process also continued after the wind change which was associated with the passage of a cold front during the progress of the fire.

Surface Winds

Change of wind direction is another most important phenomenon affecting the spread of fires and is a factor which must continually be borne in mind by fire suppression forces.

Of course, even when the average direction of a strong wind is steady, at any given point the wind direction varies quite widely on either side of the mean direction. This means that the head of a fast moving fire swings and surges left and right about its mean direction and careless fire-fighters can be quickly exposed to serious danger.

The arrival of a cold front, especially when it is associated with a sharp change in wind direction can, if precautions have not already been taken, spell disaster. The fire which occurred at Clare (South Australia) on 21 February 1965 is a good example.

In this case the fire sped rapidly through grass, savannah woodland and vineyard country, engulfing some 3-4000 acres in 3 hours over a distance of about 8 miles when the correctly forecasted cold front and its associated wind change arrived. Because it had not been possible to put out the eastern flank of the fire during its southward run, this whole flank became a very wide head fire as the wind changed sharply in direction by about 90°. The rate at which area was burnt magnified dramatically and in the fourth hour more than double the area of the previous 3 hours had been devoured.

Tactically, then, there is probably not a more important factor for the fire control officer to consider than wind direction and its likely changes.

It is in this field that the Bureau of Meteorology is able to help during the problems of fire suppression provided, of course, that it knows of the existence and location of the fire.

Topography

Topography is another aspect which affects fire behaviour greatly, both, directly, in that fires tend to run up slopes and, indirectly, in that topography has its effects on local wind patterns.

In all situations the possibilities of irregular and erratic fire behaviour is the bane of the fire-fighter and topographical variations tend to accentuate the possibilities of this happening. A classic example is the common tendency for fire whirl-winds to form on lee slopes. The diagram Fig. III shows fire whirl-wind formation on a lee slope up which a fire is progressing. This situation is the rule rather than the exception and points, from the fire-fighter's point of view, to the danger of setting back fires in this particular topographic situation.

Conclusion

It is impossible to cover all the important relationships between weather and fire in the "blow-up" situation in the space of a short talk or article. All that can be done is to try and emphasize the intricate relation between the two and so indicate that both the fire-fighter and the weather forecaster must have an appreciation of each others problems.

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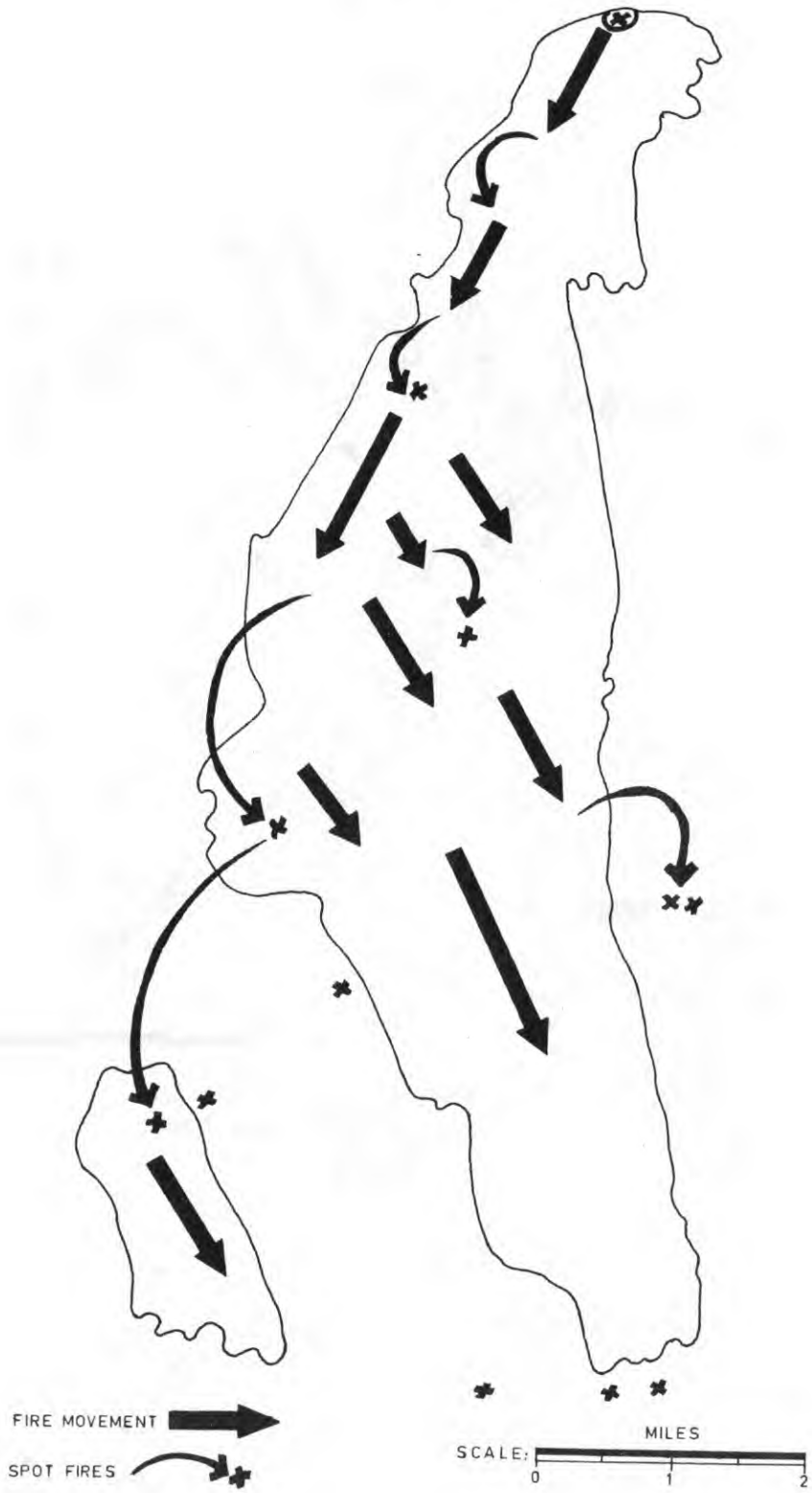


FIG. I. FIRE NEAR DAYLESFORD (Victoria) 16-1-62.
(After McArthur 1967)

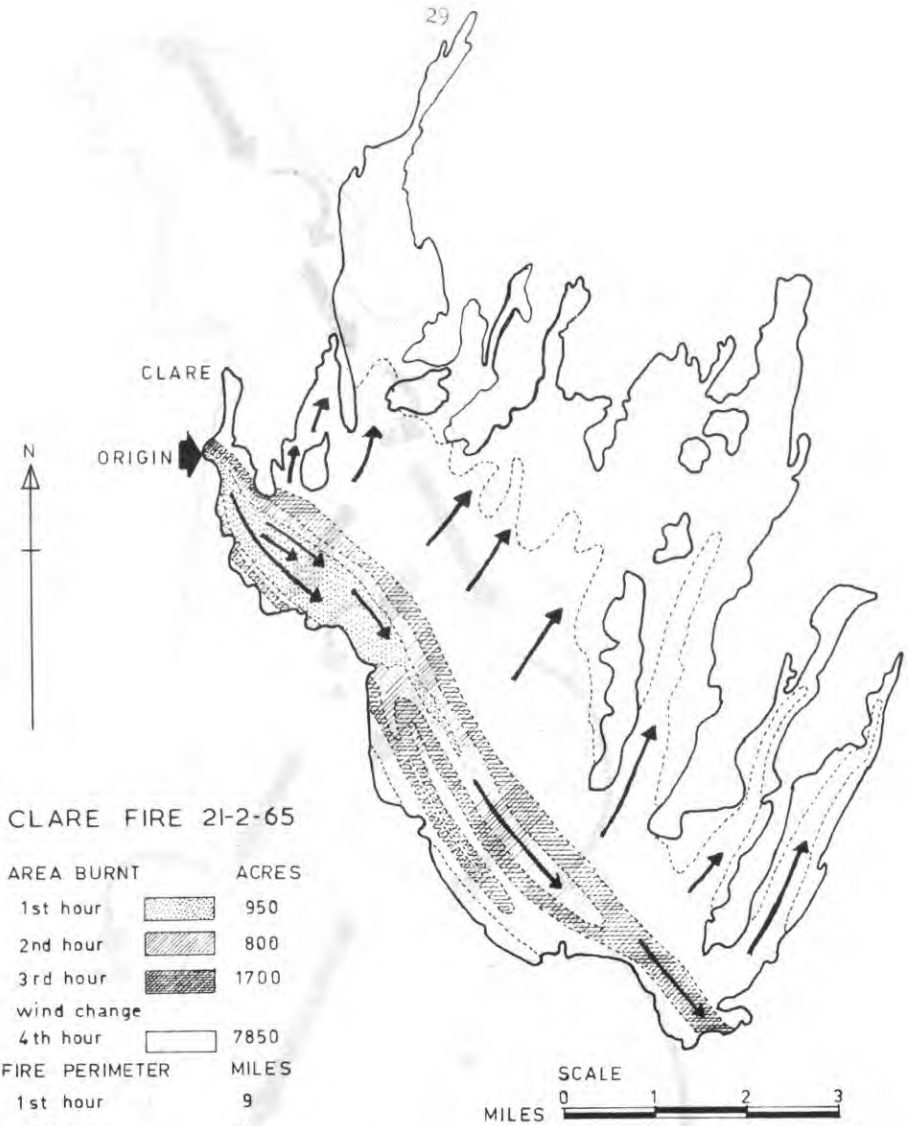
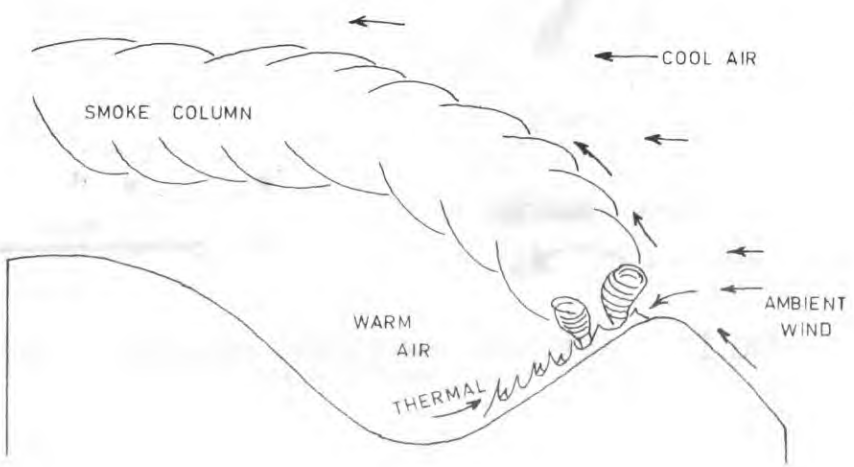

CLARE
ORIGIN
N
CLARE FIRE 21-2-65
AREA BURNT
ACRES
1st hour
950
2nd hour
800
3rd hour
1700
wind change
4th hour
7850
FIRE PERIMETER
MILES
1st hour
9
2nd hour
15
3rd hour
23
4th hour
42
SCALE
MILES
0
1
2
3
FINAL AREA approx. 20,000 acres
FINAL PERIMETER approx. 71 miles

FIG. II


COOL AIR
SMOKE COLUMN
AMBIENT
WIND
WARM
AIR
THERMAL

MORE ON 'ADA'...

The first tropical cyclone of the 1969/70 cyclone season - 'Ada' - caused much devastation on the central coast of Queensland on 17-18 January 1970. 'Ada' received wide publicity in the press, radio and TV.

Much of this was unfortunately ill-informed criticism of the Bureau's warning services. The Minister of State for the Interior, Mr. Nixon, ordered a thorough investigation of all circumstances of the Bureau's performance.

This report was personally examined by the Minister and the Secretary for the Interior, in consultation with the Director and the Regional Director, Queensland.

The Minister was satisfied that the Bureau's warning system operated in a highly satisfactory manner, that the staff of the Tropical Cyclone Warning Centre, Brisbane, and of the Meteorological Office, Mackay, performed their duties very efficiently in a very difficult situation. Alan Brunt of Queensland Regional Office has provided the following accounts of 'Ada's' visitation:

'Ada' has come and gone, leaving a trail of damage on the central Queensland coast in the Whitsunday Island - Proserpine - Mackay area. Preliminary estimates place the damage at $10,000,000 with at least 15 lives lost.

A suspicious-looking centre, detected on the satellite photographs of 5 January, was followed around the Coral Sea as a weak circulation for about ten days before the first cyclone warning to shipping was issued on 15 January.

Subsequent satellite photographs showed a definite movement towards the Queensland coast. This was confirmed by observations from the automatic weather station at Marion Reef ($19.1^{\circ}S$ $152.5^{\circ}E$). Wind observations from this station changed from 200° 50 kts at 1 a.m. on 17 January (1015 mb) to 360° 25 kts at 4 a.m. 17th (970 mb), indicating that the central core of strong winds was very small.

The first warning to the general public was based on the 3 a.m. chart on Saturday, 17 January, specifying the Mackay to Bowen section of the coast as the area which would be affected. The warnings were given newspaper headlines (e.g. the "Sunday Mail", printed 8 p.m. Saturday, had "Hayman Facing Big Blow" on page 1), but many people in the area seemed sceptical because surface winds were so light and the bars were rising slightly. They had apparently never experienced one of Queensland's "mini-cyclones", which may have little wind outside the central core and may show no pressure drop until the onset of gales. Some who had hoped to take boats to safety when the winds started found that the sudden increase of wind gave no time for safety precautions.

The centre passed about 5 miles south of Hayman Island at 1-2 a.m. on the 18th, and, after moving slowly southwestwards over the Whitsunday Passage, crossed the coast near Shute Harbour at 5 a.m. It passed twelve miles southeast of Proserpine between 7-9 a.m. on the 18th and after moving very slowly SSW, died near Calen about 3 p.m. on the 19th. There were no instrumental records of wind speed in the area of damage, but several estimates placed it at 100 m.p.h.

The scale of this type of cyclone seems almost sub-synoptic. It produced estimated 100 m.p.h. winds between the synoptic stations at Mackay and Bowen (90 miles apart) without causing gales at either of these stations. At one time Calen was reporting winds of 70/80 knots while Mackay (only 40 miles away) was reporting 25 knots. The steepness of the pressure profile can be gauged from the fact that Hayman Island's barograph showed a pressure fall from 1006 mbs at 9 p.m. on the 17th to 977 mbs at 1 a.m. on the 18th, a drop of 29 mbs in four hours, despite the cyclone's slow movement of only 5 knots.

Violent winds left a path of destruction about 30 miles wide. The worst hit areas of the Whitsunday Group were Hayman, Long, Daydream and South Molle Islands. The tourist industry suffered a severe loss as most of the buildings on these islands were destroyed or badly damaged. Trees were stripped bare of all leaves and bark, giving the impression that they had been burned by bushfires.

On the mainland, Shute Harbour, Cannonvale, Proserpine and Calen areas all suffered severe wind damage. The Proserpine and Calen regions also experienced serious flooding. Widespread disruption of communications hampered rescue work.

The first radar fix of the eye was made by Mackay at 4.15 p.m. on the 17th, when the centre was about 85 miles NNE of Mackay and 50 miles ENE of Hayman Island. The centre was then tracked by approximately hourly radar positions in a curved south-westerly direction until it started to become diffuse in the hilly country northwest of Mackay about 6 p.m. on the 18th. The 277 Radar stood up valiantly and Met. staff at Mackay should be commended for their devotion to duty under very trying conditions at one stage being isolated by flood waters.

Flooding on the coastal strip from Mackay to Bowen was severe, with major floods in the Pioneer and Don rivers as well as in numerous small coastal streams. In the areas to the west and north-west of Mackay, three-day rainfall totals (to 9 a.m. 20 January) were of the order of 30 to 45 inches: e.g. Calen 43.19 inches, Bloomsbury 41.74 inches, Mt. Charlton 33.70 inches and Proserpine 30.23 inches. The floods resulted in widespread disruption of traffic and caused the loss of at least two lives. Many homes and farms were ruined by flood waters and there was considerable loss of stock and farm equipment. Flooding also spread to adjacent parts of the Burdekin and Fitzroy river catchments, but it was not as severe as on the coast.

WEATHER PREDICTIONS BY ANIMALS

(OR WHY DO WE NEED METEOROLOGISTS?)

Extract from Pears Cyclopaedia

Cats are credited with washing over their ears when rain is approaching. Cats also become restless and wander aimlessly about the house when a thunderstorm is brewing. The braying of a donkey is said to be a sign of coming rain. Before Winter sets in, moles prepare a sort of basin in which they deposit a quantity of earthworms. When these basins are fewer in number than usual the mole-catchers state that the Winter is sure to be mild.

The field-mouse has been noticed carefully to cover up its hole prior to the setting in of cold or snow. Sheep in mountainous districts will change their feeding ground to the leeside of the hills before the arrival of severe gales and rain. Bees are very sensitive to atmospheric changes: when they return to the hive, and do not come out again for a time, rain is indicated. Working bees, when collecting honey, are said to be so afraid of bad weather that if a cloud obscures the sun they will hurry home.

If domestic geese are seen to fly without any palpable reason, rain is to be expected. If ducks are noticed going out on the grass fields in the daytime in search of snails, a shower may usually be looked for. When it is likely to be wet, garden spiders spin only short threads. When the shrill voice of the peacock is heard, a change of weather is probable. If the swallow flies high it is a sign of fine weather, but when it is near the ground, rain is to be expected.

The movements of rooks are much watched by some agriculturists as an index to the coming weather. If the rooks are seen settling noisily upon trees and flying hither and thither instead of going straight away, a wet day is probable. If they are flying low in the Winter, going and returning silently, early and late, before sunrise and after sunset, a sharp frost may be looked for. Fish are extremely sensitive to the weather, as the angler well knows, many species declining to feed when a change is in progress.

ADELAIDE'S RECORD RAIN

by

H. A. LINDSAY

Adelaide, capital of South Australia, stands on a plain ten miles in width, at a spot approximately midway between the Mount Lofty Ranges and the sea. The climate is typically 'Mediterranean' with a hot, dry Summer and a wet Winter. The annual rainfall averages 20 inches.

Occasionally, a monsoonal depression strays south. Adelaide then receives a sample of tropical Summer rain. The outstanding example of this occurred in 1925. At the time I was supervising the erection of a building on the lower foothill slopes some 4 miles to the southeast of the city proper. The site was sufficiently elevated to give a good view over the city and part of the plain.

The 6 February 1925 was a day of high humidity and a sky clear except for a few cumulus clouds. Next morning the humidity was even higher. The weather map, published at 9 p.m. on the previous evening, showed that a widespread monsoonal depression, which had been centred over Queensland, had moved southwest to cover most of South Australia. The forecast was:

"Continued hot and sultry weather with thunderstorms"

By 10.30 a.m. two huge masses of cumulonimbus cloud had gathered, one over the Port River to the northwest of the city and the other over the foothills to the northeast. They began to creep towards each other. Standing on a wall of the building and watching the roof principals being hoisted into position, I wondered what would happen if those two cloud masses met. Would I witness the birth of a tornado? Would one cloud pass under the other? What would be the result of the turbulence thus set up?

By noon we could see grey veils of rain falling from both clouds, which were now a little to the north of the city and so close that only a narrow ribbon of sky separated them. "They are going to meet!" I said to a carpenter from Queensland. "There'll be fun if they do" he replied. "I've seen it happen up north". When I enquired what happened in such a case, he said: "Anything from rain by the bucketful to hailstones like golf-balls". From our point of vantage, we could see little sign of obvious turbulence when the clouds did meet. They merged, darkened and seemed to rise much higher into the sky. But the grey curtain of rain darkened rapidly until it was an indigo-black wall, against which the taller buildings and the church spires of the city stood out in sharp relief.

Then the storm moved south. One by one the outlines of the buildings blurred for a moment, then vanished into the inky curtain of rain, across whose face dazzling rods of lightning darted almost continuously. Through the still, muggy air came a low, sustained roar, punctuated by booms and rumbles of thunder. Then a tongue of cloud crept over the sun and the picture lost its sharp colour contrasts. Within 20 minutes the rain reached us. It did not "fall in sheets", as I have seen a tropical downpour described in print. Far more apt was the description of a monsoon downpour in India, "raining ramrods". That is exactly the impression created to the eye - pencil-like rods of water falling so thickly that objects a few yards away were seen as a blur. A billycan put out as a make-shift rain gauge caught over 3 inches in an hour, nearly a third of which fell in 10 minutes.

In the middle of the downpour, two men, who were sheltering in a toolshed, looked out to see flames and smoke inside another shed which held a few tons of unslaked lime. It had become wetted by water leaking through the roof. With the best of intentions, they dashed out and used a couple of putlogs to knock the roof off, thinking it would put out the fire to let the rain in, but of course, the effect was to turn the shed into a miniature volcano spouting steam, flames and pieces of burning sacks!

The heaviest official gauging in and around the city was 6 inches in $2\frac{1}{4}$ hours, of which 0.66 inches fell in 7 minutes. As the Divisional Meteorologist, Mr. E.E. Bromley, pointed out next day, it was indeed fortunate that the deluge fell on the plains. Had it fallen on the nearby ranges, torrents would have swept down all the valleys, causing immense damage and heavy loss of life. In the official records running back to 1839, there had been nothing to approach this fall, except when two great masses of comulonimbus cloud had met in the same way above the foothill suburb of Mitchem some 30 years previously, resulting in a heavy but localized downpour of the same type.

On 7 February 1925 according to one eyewitness, the deluge "made the streets of Adelaide look like the canals of Venice". Severe damage was caused to stocks in many of the big stores, for watertables and roof gutters could not cope with such a flood. The fire brigade had a busy time pumping out basements.

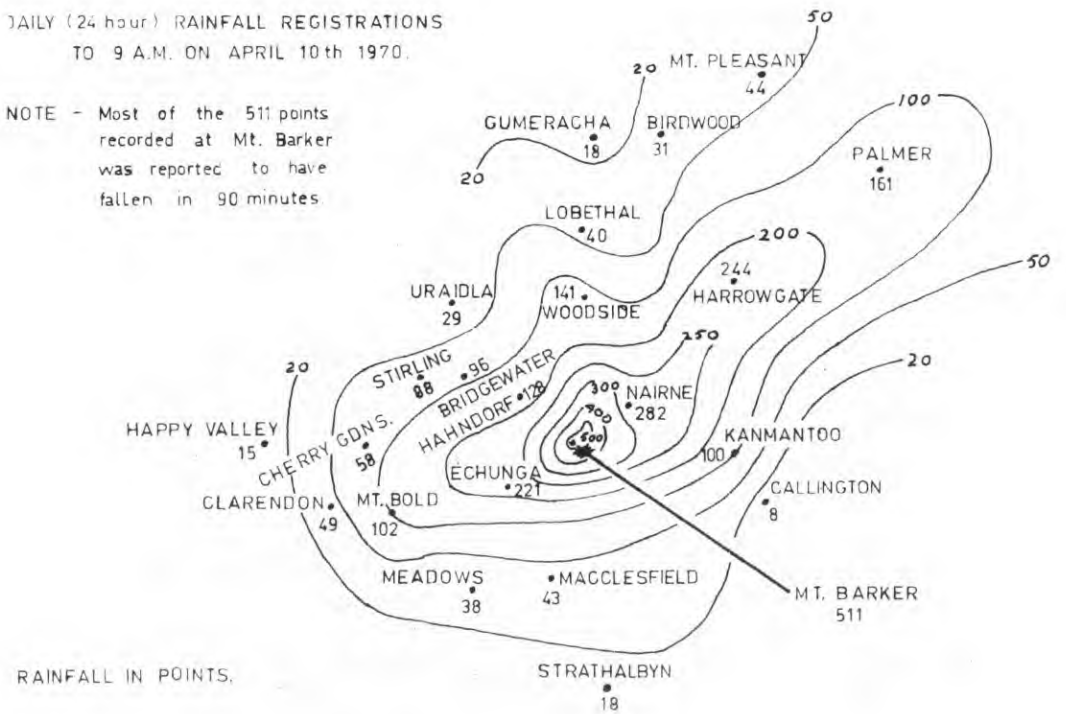
Some 20 years later I saw many heavy tropical downpours, especially in the island of New Britain. The wartime base at Jacquinot Bay was an especially wet spot. The Meteorological Officer of the Royal New Zealand Air Force, whose airstrip we were guarding, said that it would be interesting to know what the rainfall was in some of the valleys high on the mountains which lay between us and the Japanese base at Rabaul. Judging by the rain-clouds which drifted up those valleys nearly every day, and the strong streams running out of the mountain creeks, he was of the opinion that the rainfall up there would be at least three times the 200 inches per year which he had recorded at the airstrip. It would therefore exceed the annual total recorded at the world's two known wettest spots in India and Hawaii.

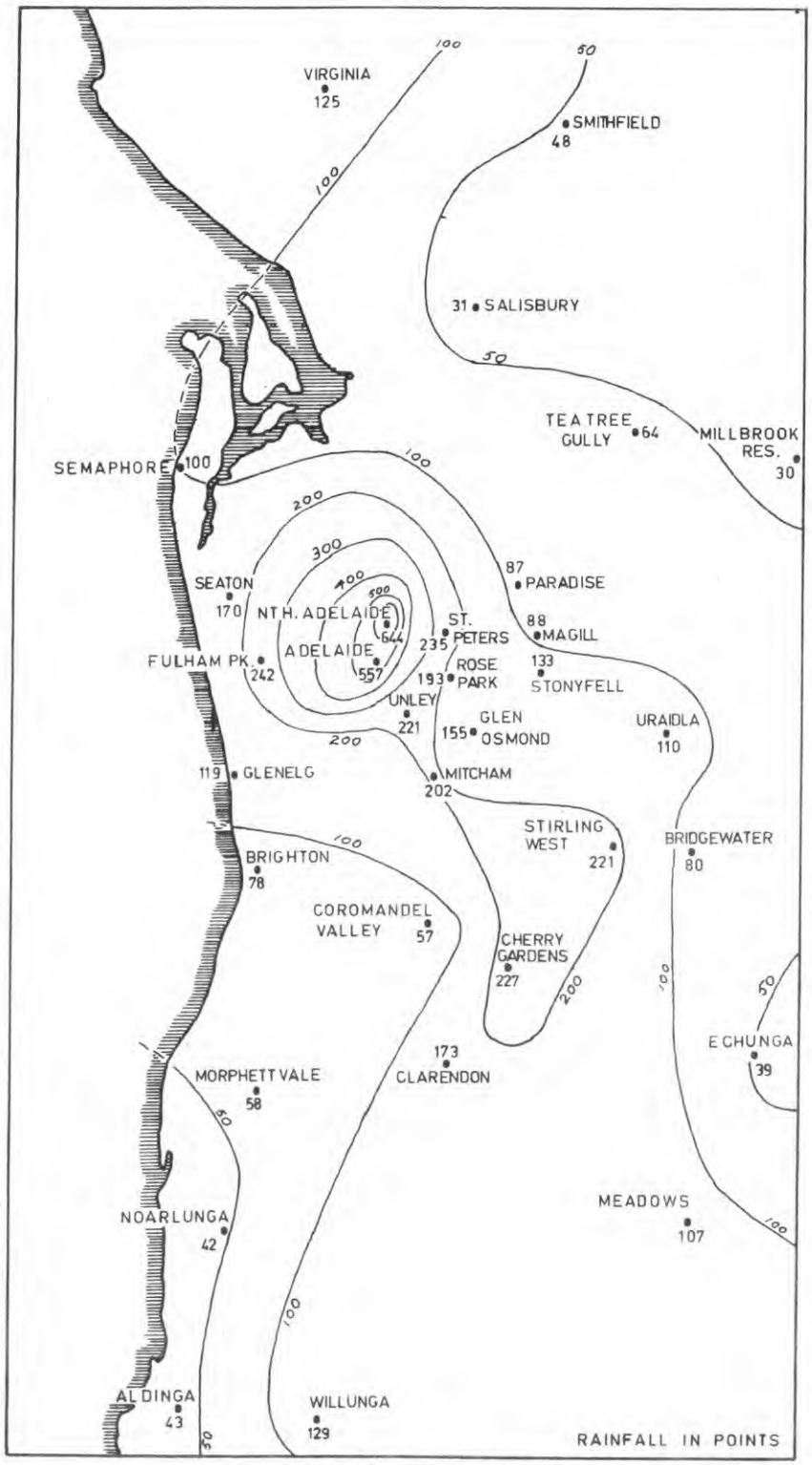
The heaviest rainfall while I was at Jacquinot Bay was 48 inches in 40 hours, most of it falling in the first 12 hours. But at its heaviest it was only a drizzle when compared with the fall of 0.66 inches in 7 minutes which established Adelaide's record for a heavy fall.

Footnote

A more recent instance of very intense rainfall in South Australia occurred on the evening of 9 April, 1970 when a thunderstorm at Mount Barker in the Adelaide Hills produced 511 points, most of which fell in under two hours.

Considerable local flood damage was sustained by Mount Barker itself and 20 miles to the Southeast at Langhorne Creek where the heavy rain caused the Bremer River to rise suddenly on the following day.





ADELAIDE'S RECORD RAIN
7th February 1925

WAVES ON THE SOUTHERN COAST OF AUSTRALIA

by

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Introduction

South of Australia lies the Southern Ocean, the only ocean completely surrounding the earth in an east-west direction. Across the surface of this ocean moves a continuous belt of cyclones and anticyclones, the strong winds associated with them producing the roughest seas in the world. The waves produced reach our southern coast with little loss of energy and the swell is so pronounced that Snodgrass and others (1) have tracked it from New Zealand to Alaska by means of a series of recorders spaced out across the Pacific.

The only waves to be recorded instrumentally on our south coast have been at Port Neill and Port Giles by the S. A. Department of Marine and Harbours, at Cape de Couedic and Macquarie Island by the Horace Lamb Centre for Oceanographical Research, at Point Lonsdale by the Shell Company, and at Grange by the Civil Engineering Department of the University of Adelaide. Of these, only two instruments are still recording, and they are in very sheltered locations not at all typical of the open coast.

The Necessity for Systematic Wave Recording

Since 1965 many organisations have found the need to use wave data from the Southern coast of Australia. The only available records were visual observations made by lighthouse keepers, observers on ships, etc. There was hardly any instrumentally recorded data.

Civil engineers, planning the position and design of new harbours and modifying existing ones for the use of deep draught bulk carriers, needed to know the nature of the sea and swell at various locations. They were concerned with long period waves which may cause harbour oscillations which can occur in harbours facing a wide ocean. These oscillations can be sufficient to damage ships moored to a quay and snap mooring ropes if they are not kept continuously tight.

Interaction of waves can also cause unusual sea conditions near harbour mouths. This adds considerably to the difficulty of handling ships entering or leaving a harbour, and the increased pitching and heaving can greatly reduce underkeel clearance. It motivated one shipping line to propose an investigation of the effect of waves on their tankers as they passed through a narrow sea channel of restricted depth. At the beginning of the survey there existed little information on the nature of the waves to be expected. Conditions were much worse than anticipated, to such an extent that

a number of wave-rider buoys, used to record the waves, were either lost or damaged beyond repair.

A passenger service looking into the possible use of a hovercraft required an estimate of the proportion of time the state of the sea would be suitable for the operation of the vehicle. They were mainly concerned with waves in shallow water along the coast, and between the mainland and offshore islands. It was in similar situations that several hovercraft were badly damaged off the English coast in July, 1966.

Engineers designing a new sewerage drainage scheme were concerned about the interference of waves with a proposed effluent outlet into the ocean. They had to be sure that the outflow would be continuous under all possible conditions. Therefore a knowledge of the usual sea conditions over all seasons was needed before designing the outlet.

The wave history of a badly eroded beach was needed so that coastal engineers could plan remedial action. Short steep waves are most effective in eroding beaches and depositing the eroded material at greater depths to seaward off the beach; long, low swell returns the material to the beach, and if it comes at an angle to the beach it is very effective in moving material along the coast. Similar factors influence the growth and movement of sand bars, which can be a nuisance in the approaches to a boat haven or a harbour.

An oil exploration company wanted to know the sea conditions their oil drilling rigs should be designed to withstand. Several years ago a catastrophe occurred in the North Sea, because waves, much higher than expected, dislodged the legs of a drilling rig.

In all cases, preliminary investigations were complicated by the lack of reliable wave data. Each group was faced with the problem of installing wave recorders and waiting for long periods before making any assessment of the situation. Often several years are required to ensure that the wave data is truly representative of the sea conditions. If systematic recording and analysis of wave data from our southern coast had been initiated in the past, more would have been known about our wave conditions, and each of the above groups could have gone ahead with preliminary plans without lengthy delay.

In the past some organisations have taken a chance on local hearsay, visual wave observations, or hindcasting of waves. These can be misleading. At one place a probability study based on hindcasting and rather sketchy wind records indicated that buoy mooring of tankers would be successful on most days of the year. Since the completion of a refinery nearby, it is not uncommon to see tankers anchored off the shore for several days, being unable to discharge their cargo due to the unfavourable sea conditions.

An examination of visual wave observations can mislead since even experienced observers cannot detect small changes in wave height or period, and tend to overestimate the height of low waves and underestimate high waves. Figure 2 compares the wave height estimated by an experienced sea captain with the significant wave height computed from data collected by a wave-rider buoy, during tanker trials at Port Phillip Heads in September, 1965. At times the estimates were more than 40% in error.

The Spectral Analysis of Wave Records

Wave records can be analysed in several ways. A knowledge of significant wave heights and periods was once considered adequate to describe the state of the sea surface, but it is now known to be insufficient to predict the effect of waves on ships and coastal structures.

Ocean waves contain energy continuously distributed over wide frequency bands. For the same total energy the frequency distribution may differ considerably. Figure 3 shows energy spectra computed from three wave records taken during tanker trials at Point Lonsdale near Melbourne in August-September, 1965 (2). The wave energy represented by each record was the same, but the distribution and resultant effects on the heaving and pitching of the tanker differed greatly.

Routine computations of wave spectra can serve applications other than those cited previously. Aproaching high swell first appears in the spectra as a small peak in the frequency range 3-4 cycles per minute. This is evident more than 24 hours before the arrival of high swell, and long before the rising height of the swell among the local waves makes it perceptible to the eye. Such fore-warning would be our equivalent to the routine swell forecasts carried out from a knowledge of the wind fields over the oceans on the northern hemisphere. The same procedure cannot be adopted here because the wind field over the Southern Ocean is comparatively unknown. The advantage of such swell warning to owners of fishing vessels and other small craft is obvious.

Correlation of wind information with wave spectra can yield more insight into wave formation and propagation processes. The continuous west-east flow of cyclones and anticyclones in the 40°-70° latitude band, makes the Southern Ocean one of the few regions in the world where a fully developed sea can be expected. As yet little is known about wind generation of waves in this Ocean.

Storm Detection from Wave Records

Storm centres south of Australia generate a spectrum of waves including long period swell which has been detected as far away as Alaska (1). The rate of change of the frequency band of this swell is related to the distance it has travelled. Therefore a knowledge of its rate of change should make it possible to detect and track these storms. This information would supplement other data received from this area.

Storm centres travel with speeds of the order of 20 m. p. h. The long period swell generated within the storm is of very small amplitude, but its energy propagates over the sea surface at approximately 100 m. p. h. At a distance of 2, 000 miles from a storm centre fore-runners give an indication of approaching bad weather within one day, and several days ahead of its arrival.

It has been shown that an estimate of the distance X miles of the storm centre from the recorder is given by

$$X = 2,500 \Big/ \frac{(df)}{(dt)} \qquad \ldots(1)$$

where f cycles/minute is the peak frequency of the fore-runners in the record taken at a time t days (3). Examination of energy spectra of successive wave records from a shore station give a measure of $\frac{df}{dt}$ and hence of X.

During January 1965, an unsuccessful search was made for available south coast wave data to test the use of formula (1). Since that time some wave records from Macquarie Island, Point Lonsdale and Port Neill have been analysed, and the energy spectra of these records used to successfully detect a number of storm centres in the Southern Ocean.

Figure 4 shows spectra for successive wave records taken at Point Lonsdale on the 3 and 4 February 1966. The change in peak energy and frequency with the passage of time is clearly shown. Application of equation (1) to the frequency change of peak D indicated the presence of a storm 2900 miles from the recorder on the morning of 28 January; the frequency change of peak E indicated the presence of a storm 2300 miles from the recorder on the morning of 31 January.

In the main, comparison of the spectra of these waves with those obtained from other oceans reveal two main differences. Firstly, the long period fore-runners of storms are much more prominent in our waves, and their frequency and energy change more quickly. Secondly, their energy content is generally greater than that of waves from elsewhere, and this energy is centred around a higher period (about 15 seconds).

Conclusion

Systematic collection of instrumentally recorded wave data along the southern coast of Australia is necessary for both practical and scientific purposes. Besides supplying an immediate fund of data for future engineers and ship owners, it will produce information of a more fundamental nature concerning the interaction of the atmosphere and sea surface in the Southern Ocean.

Acknowledgment

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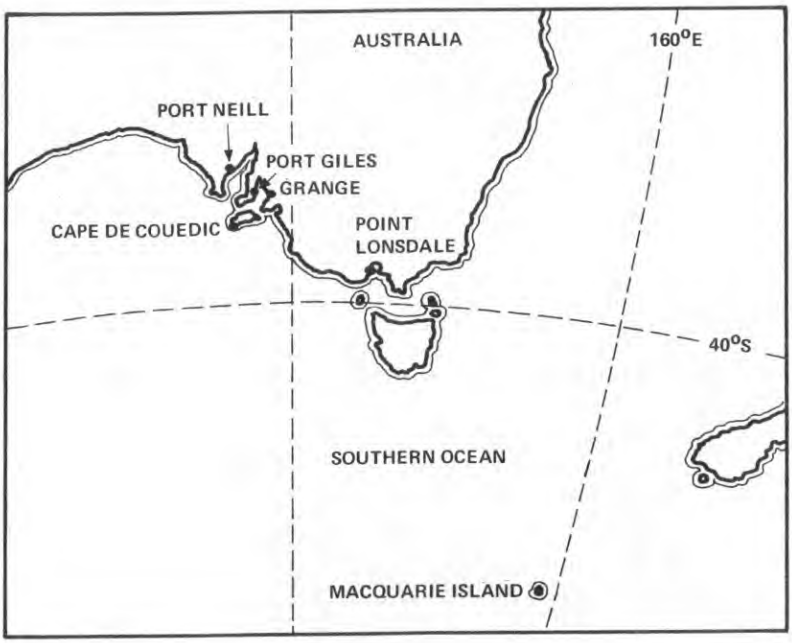

Figure 1 : Map of Australia and the Southern Ocean showing the location of wave recorders which have operated south of Australia.

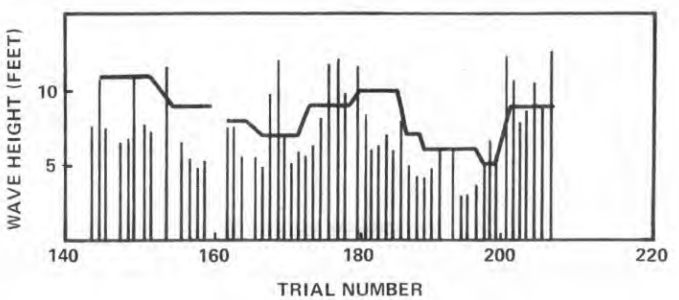

Figure 2 : The horizontal line indicates the wave height estimated by an experienced observer; the vertical lines give the significant wave height recorded instrumentally.

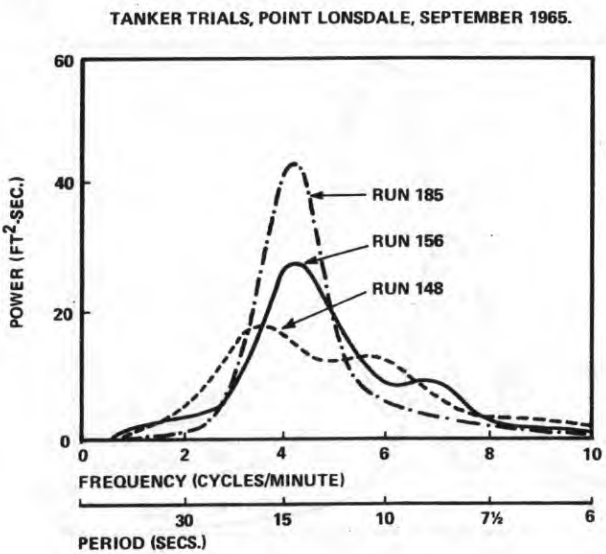

Figure 3 : The total wave energy and the significant wave-height (6.7 ft) are the same for all three wave samples. However, for Run 148 there are two distinct energy peaks at periods of 18 and 11 seconds, for Run 156 there is a dominant peak at 14 seconds and a minor peak at 9 seconds, and for Run 185 there is only one peak at a period of 15 seconds.

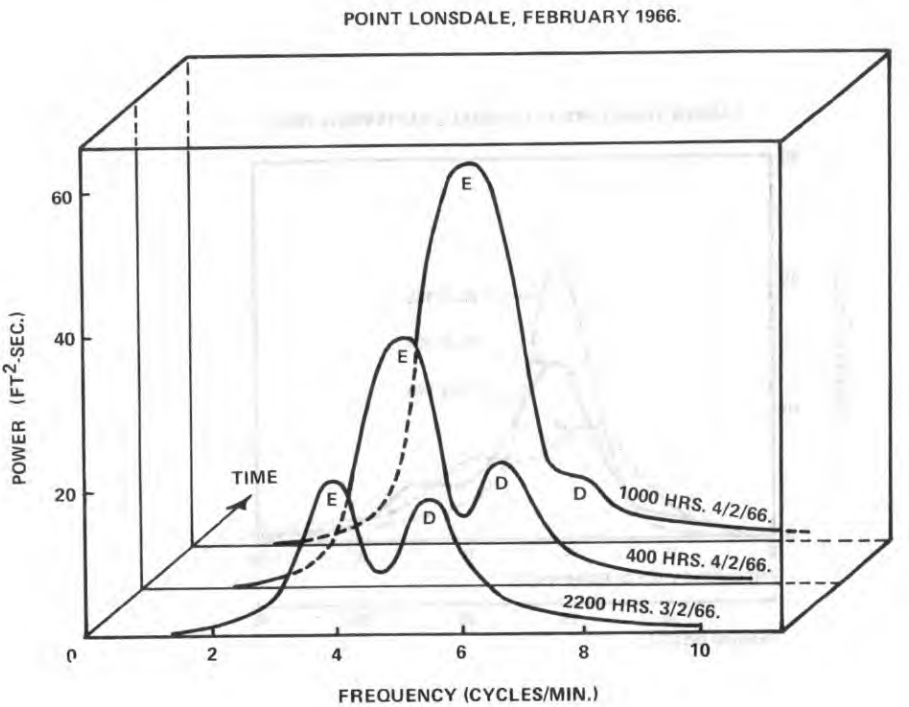

Figure 4 : Spectra of wave records taken at six-hourly intervals. The frequency peaks of D and E increase with time: the energy in peak E is increasing while that in peak D is decreasing.

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